PFEIFFER

Power Requirements of Industrial Machines

Electrical Engineering

M. S.

1913

POWER REQUIREMENTS
OF INDUSTRIAL MACHINES

BY

BENJAMIN SALISBURY PFEIFFER

B. S. University of Illinois, 1912

THESIS

Submitted in Partial Fulfillment of the Requirements for the

Degree of

MASTER OF SCIENCE

IN ELECTRICAL ENGINEERING

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

1913

UNIVERSITY OF ILLINOIS

THE GRADUATE SCHOOL

May 31 1913

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Benjamin Salisbury Pfeiffer

ENTITLED Power Requirements of Industrial Machines.

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Master of Science in Electrical Engineering

Ernst Berg
In Charge of Major Work

Ernst Berg
Head of Department

Recommendation concurred in:

Morgan Brooks.
J. M. Bryant
Ellery B. Paine

Committee on Final Examination

POWER REQUIREMENTS OF INDUSTRIAL MACHINES.

CONTENTS.

POWER REQUIREMENTS OF INDUSTRIAL MACHINES.

Since one of the chief phases of the engineering field is the application of power to industrial machinery, and since the use of electric drive is making great strides in the competition with steam and other motive powers, the necessity of more detailed information in this regard is increasing rapidly.

The purpose of this work is to show the advantages of electric drive for all kinds of industrial machinery and to give data which will enable the engineer to compute the power required for any installation. It is proposed to take up the different branches of manufacturing separately for in some cases special considerations enter which are not applicable in others.

Some of the more important industries will be taken up more in detail. One of the oldest applications of electric power is metal working machinery. For that reason it was much easier to obtain data concerning this industry as only with the application of electricity to the driving of separate machines was any definite knowledge had of the power required to drive them. The application of electricity to agriculture is however practically a new thing and data concerning it are very meager. The companies manufacturing the machines to be driven are very diffident in giving information regarding the power requirements of their machines as they in most cases manufacture prime movers themselves. The power requirements of an industry does not only mean the HP required but must also include the conditions under which the machines are operating. It will be seen that the power requirements of a cement mill and a refrigerating plant would differ considerably although they both

might require the same HP. These important considerations will be dealt with at some length in the more extraordinary cases.

AGRICULTURAL PRODUCTS.

In comparing electricity with other forms for farm work it is seen that its chief advantages are reliability, cleanliness, safety and flexibility in application. To convince the practical farmer however, the economic value of electricity for farm work must be shown. The nature of the farm determines to what extent the application of electricity may be carried. Where the buildings are scattered, the application of motors is much cheaper than to put an individual engine in each building. Where available central station power is more satisfactory, but for isolated farms, compact generating sets, utilizing various prime movers are now coming into use. Local conditions influence the choice of these prime movers to a great extent. The electric motor can be readily applied to all classes of farm machinery. The motors required are usually light in weight and require no special foundations. If A.C. induction motors are used there is no sparking and consequently no fire risk. If D.C. motors are used the motor must be placed in a separate building or well covered, on account of the danger from sparking. Individual drive is more economical on account of the intermittent use of the machinery. In some cases a portable motor is used which reduces the first cost of installation. The possibility of farm lighting is an important factor aside from the convenience it affords. During the harvest season when time is very essential bright lights can be supplied which will enable two shifts to be run. The minor applications of electricity to farm use will be treated under separate heads such as laundry machinery, machine shops, etc.

Agriculture, cont.

An industry which has the closest relation to agriculture but which may not be classed with it by some writers is the flour milling and grain elevator industry. Here as on the farm, the absence of shafting and the flexibility of electric drive is very important. By the use of induction motors constant speed can be obtained and in grain elevators this is necessary for the best operation. Central station power obviates all necessity for engineer, fireman, etc. and since the induction motor is a very simple device, it requires no expert attention. As to the advantages or disadvantages of central power it seems best for the smaller plants at least to adopt this. In Minnesota 70% of mills electrically operated are using central station power.

Included under agricultural products are all industries directly related to it such as the meat packing and slaughtering industry. This also includes the distribution as represented by the butcher. One of the most important applications of electric power to this industry is in the refrigerating machinery but as a separate chapter will be devoted to this division, it will not be discussed in detail at this time. Although the large packers have been among the earliest users of artificial refrigeration, it is only recently that the retailers as well as the wholesalers have installed small units for their own use. Meat is very perishable, and if it is to be kept in the best of condition, requires the best possible conditions in its surroundings. The shortcomings of cooling by means of ice are accentuated in this business because the damp musty atmosphere makes the meat slimy

on the surface, requiring considerable trimming to waste if the meat has been exposed to such an atmosphere for any length of time. It is this saving which in some cases more than covers the cost of power consumed that makes artificial refrigeration possible.

Applications.

Cylinder corn sheller
Capacity 2 tons/hr. 400 RPM. 25 HP

Butter churn and worker (Simplex)
Capacity 300 Gal. 150 RPM. 2 HP

Cream Separator (Delaval)
Capacity 1350 lb./hr. 6000 RPM. 1.5 HP

Fodder Cutter (Ohio #14)
Capacity about 3 tons dry fodder per hr. 840 RPM.10 HP

Grinding Mill (Scientific)
Capacity 40 bu. (corn & cob) per hr. 730 RPM. 15 HP

Grinding Mill (Davis Attrition)
Capacity 40 bu. ground corn/hr. 1800 RPM. 25 HP

Grist Mill (Richmond)
Capacity 111 bu. rolled oats/hr., 70 bu. cracked corn/hr. 800 RPM. 25 HP

Root Cutter (Massey-Harris)
Capacity about 6 tons turnips/hr. 220 RPM. 2 HP

Sausage Grinder (Enterprise)
Capacity 750 lb./hr. 440 RPM. 4 HP

Sausage Stuffer & Triplex Pump
Capacity 116 lb./hr. for two men. Total power 0.75 HP

Shredder and Husker (6 roll)
Capacity 2.6 tons/hr. 1000 RPM. 15 HP

Oat Clipper, Invincible, Size, Capacity and approx. HP required.

Size, No.	1	2	3	4	5	6	7	8	9
Bu./hr.	60	90	120	160	200	400	600	800	1200
Est. HP	6	7	8	9	10	12	15	25	40

Agriculture, Cont.

An example of the best installation of flour milling machinery is that of the Wasco Warehouse Milling Co. at The Dalles, Ore. The building is seven stories high and built entirely of concrete and steel. The present capacity is 1,300 barrels and the ultimate capacity will be 2,750 barrels. The installation is as follows:

No.	Application.	Horsepower.
1	Main Drive	300
1	Cereal Mill	15
1	Barley & Graham Mill	50
1	Wheat Receiving	35
1	Wheat Scouring	35
1	Wheat Scouring #2	15
1	Flour Packers	15
1	Feed Packers	15
2	Humphrey Elevators	3
1	Automatic Sprinklers	5

The control of all the motors is centralized on a main switchboard, located in a separate room especially designed for that purpose. There is not an exposed current - carrying live part on any of the apparatus, which fact eliminates all possibility of accident to employees, and insures continuous service so far as the motors are concerned.

Agriculture, cont.

Applications.

1700 acre rice plantation, Ellis, La., near Crowley. Prime mover is a Fairbanks-Morse 200 HP. Four Cylinder, Slow speed oil engine running on low grade oils, direct connected to 170 K.V.A. 2300 V., 3 phase, 60 cycle alternator, with exciter and switchboard. This provides current for operating three 75 HP vertical squirrel cage 2200 V motors direct connected to vertical centrifugal pumps. One pump is located at the power house, the second three quarters of a mile away, and the third a half mile further, or one and a quarter miles from the power house.

ATTRITION MILLS.

Attrition mills are used in the shelling of corn and grinding shelled corn, oats, cotton seed cakes, etc. They are also used extensively in flour feed and cotton seed oil mills. The squirrel cage induction motor is used exclusively with these mills. The size of mill is expressed in inches, referring to the diameter of the grinding plates. The sizes most commonly found in flour mills, with size and speed of motor are as follows:-

Size of Mill ---------	20	24	30
HP of Motor ----------	10	15 & 20	25 & 30
Speed, RPM -----------	1740	1740	1710

In grinding cotton seed cakes the 32" and 36" mills are used, the former requiring 25 to 40 HP, 1710 RPM motors, and the latter 40 to 50 HP, 1140 RPM motors. One standard auto-starter with no-voltage and over-voltage release attachments is used for starting both motors.

APPLICATION OF POWER FOR THE BUTCHER.

Every retail butcher has as part of his equipment a meat grinder for preparing sausage or hamburg steak. These are very generally operated by motor. The amount of electricity used is nominal, but the amount of labor and time saved is considerable. A very wise practice which has been adopted by some is to set up the cutter in the refrigerator box. By so doing the necessity of cleaning it every hour or so in hot weather is avoided. Several sizes are on the market for both direct and alternating-current circuits, built as a unit with the motor and machine on a common base and a worm-gear drive, with capacities as follows:

0.5 HP	Capacity	per	hour,	200	pounds.
0.75 HP	"	"	" ,	300	"
1.00 HP	"	"	" ,	400	"
3.00 HP	"	"	" ,	1500	"

The capacities have reference to beef. Pork is cut more easily and faster, so that the capacity in pork will be about 75% higher.

For applications of refrigerating machinery will be found in the chapter on refrigeration.

The best system for the retail butcher is direct expansion, used either with automatic thermostatic control or with auxiliary brine tank. Where special rates for electric power are given for off-peak agreements, the automatic control cannot, of course, be used without some special cutoff switch, but it is the ideal in this business. A uniform temperature of 34 to 36 degrees is the best to keep meat in perfect condition. If the temperature is reduced much below 32 degrees beef will darken and look unsightly.

With the non-automatic machine, an auxiliary brine tank should be used. This acts as a storage reservoir and maintains a lower temperature than would otherwise be possible over nights, Sundays, and holidays when it is inconvenient to operate the ammonia compressor.

The load factor in this industry is very low in most cases although there are instances where it runs as high as 42%.

BREWERIES & BOTTLING WORKS.

The possibilities of the application of electric drive to this industry are among the most promising of any. The manufacturers have themselves been very progressive in adopting improvements and have been quick to realize the many advantages of electric drive. The improved sanitary conditions, the greater flexibility as well as the reduced cost, have been the most important factors in deciding this. Additional advantages are: space economy, and saving of power due to the elimination of shafting and belts; the simplicity of power distribution allowing for additions or changes; and the easy control of each individual machine.

The induction motor is generally used, although in many plants direct current motors are used. The absence of sparking and constant speed are the chief advantages of the former.

One of the most important phases of the brewing industry is the subject of refrigeration. This will be taken up under a separate head. The subject of pumps will also be covered in another section.

Individual motor is applicable to all of the following: rice cookers and mash tubs; chip-washers; keg washers and pitching machines; hooping machines; bottling machinery.

Applications.
Electrical Installation at the Plant of the Acme Brewing Co., Macon, Georgia

Machine	H.P.	R.P.M.	No. of Motors	Method of Connection	Remarks
Washing Machine	7.5	1800	1	Belted	Moisture proof windings
Tank room agitators	5	1800	2	Belted	" " "
8 by 8 compressor.(air)	15	720	1	Belted	Automatic pressure reg.
Machine shop	5	1800	1	Belted	Lathe, drill, shaper, 2 stones
Centrifigal pump	10	900	1	D-C	350 g,p,m, against 30 lb.
Mash tub	15	720	1	Geared	Cap.16,000 lb.of material
Mash conveyor	2	1800	1	Geared	Back geared motor
Mash pumps	2	1800	1	Geared	Speed reduction gear box
Malt cleaning and rolling	7.5	720	1	Geared	Direct to rolls
Blower for grinder	1.5	1200	1	D-C	Special shaft extension
Beer pumps (4)	5	1800	2	Belted	Moisture proof belts
Barrel shop	2	1800	1	Belted	Repairing kegs
Bottling works	7.5	1200	1	Belted	
Mangle	2	1800	1	Belted	For drying clothes
Triplex pump	20	1200	1	Belted	260 g,p,m, against 200'head
Centrifugal pump	10	1800	1	D-C	Wash room
Carpenter shop	15	1200	1	Belted	Saws, planer, etc.
Forge fan	2	1800	1	D-C	Special shaft extension
Elevator (2 ton cap.)	15	820	1	D-C	Intermittent rated motor
Mash dryer	10	1800	1	Belted	
Grain elevator	5	1800	1	Belted	
Centrifugal pump	5	3600	1	D-C	
Centrifugal pump	15	720	1	D-C	
Ice hoist	5	1800	1	Belted	
Electric crane		Self-contained hoist and motor.			
Av. load fact. 23%					
Pressure pump	2		1	D-C	Circulating brine pump
25 BBl Pasteurizer	3		1	Belted	
Keg Scrubber	3		1	Belted	
Brine pump	3		1	Belted	
Compressor	5	900	1		Carbonic gas 1-3"
Malt Mill	10	720	1		Kaestner & Co.
Centrifugal pump	15	900	1		Refuse, 5"
Beer pumps	2	1800	1		2-1/2 x 4" piston
Beer pump	2	1200	1		2" rotary
Triplex pump	1	1800	1		3 x 4" Deane
Agitator, rotary	4	900	1		
Agitator, Mash tub	15	720	1		
Agitator, Mash tub	10	900	1		
Brine pump	2	1200	1	Belted	
" "	1	1800	1	"	4 x 5"

Bottling Works.

In discussing the application of electricity to this industry it must be remembered that there are two distinct classes of bottling works, those in which pasteurizing is necessary and those where it is not. Beer and milk bottling plants are typical in the former classification and mineral and "soft-drink" plants in the latter. The difference exists when the question is debated whether power for driving the machinery should be obtained from the central station or generated on the premises. While hot water is used in all plants for washing purposes, pasteurizing plants require considerable amounts of steam.

The operations involved in bottling beer comprise, first, soaking the dirty bottles as they are returned to the shop, in a 3 percent solution of caustic soda. From the soakers the bottles are conveyed to washing machines, then to fillers, crowners, through the pasteurizer and then to the labeling machines. From these the bottles are placed in cases or otherwise packed for shipment.

The motor requirements of the milk-bottling establishments are simple, as all apparatus may be run at constant speed. Most of the motors must start under load unless there is provision made for a clutch. On account of the wet condition and frequent washing of floors, etc., it is desirable to have the motors mounted overhead or otherwise protected from the moisture. This applies to all bottling shops.

Bottling Works
Applications.

Load-factor, 5.3 per cent.

MOTOR INSTALLATION

The following is a list of the motors installed with their respective drives. The supply source is three-phase 60 cycles, 220 volts. All motors are of the squirrel-cage induction type.

No.	Horse-power	Speed R. P. M.	Application.
1	0.5	1,200	Belted Direct to a pulp washer.
1	3	1,120	Direct connected to a small portable wine pump.
1	5	1,650	Belted to pump for raising wine from tank cars to storage vats, a distance of 95 feet.
1	10	900	Belted direct to a six-ton ice machine for cooling wine cellars.
1	3	1,120	Belted to a line shaft driving one American Soda Fountain Company's carbonator; one Blessting and Bastian carbonator; and one Crown Cork & Seal Company's combination filler and crowner. This machine fills three bottles at once and has a capacity of 20 quarts per minute.
1	2	1,120	Belted to a line shaft driving two Twentieth Century bottle soakers.
1	5	1,120	Belted to a line shaft driving one air compressor (120 pounds pressure)
1	1	1,650	Geared to crystallizing wheel.
1	2	1,120	Belted directto one E. Ernold corking machine.
2	0.25	1,200	Each driving a Miller capping machine.
1	3	1,120	Belted direct to a cut-off saw.
1	5	1,120	Belted to line shafting driving a small machine shop.
3	10	1,200	Each driving mechanism of a two-ton freight elevator.
1	5	1,120	Driving horse-grooming equipment in stable

Load-factor, 16 per cent; operating-time load-factor, 34 per cent.

MOTOR INSTALLATION.

The following is a list of the motors installed with their respective drives. The supply source is 220 volts, direct current.

No.	Horse-power.	Speed R. P. M.	Application
4	1	600	Each belted direct to a Twentieth Century Machine Company's soaker, each having a capacity of 6,000 bottles per hour.
2	1	600	Each belted to a Twentieth Century Machine Company's soaker. Capacity of each, 4,500 bottles per hour.
6	1	900	Each belted to a Universal rotary washing and rinsing machine. The capacity of each machine is 3,000 bottles per hour.
6	0.5	850	Back-geared motors, each driving a short belt conveyor, carrying bottles from washing machines to the fillers.
11	1	1,200	Each motor belted direct to a Bishop & Babcock rotary bottle filler. Each machine has a capacity of 90 to 110 pint bottles per hour.
10	1	600	Each motor belted direct to Crown Cork & Seal Company's crowner.
1	4.5	600	Belted to conveyors for carrying bottles from crowning machine to packers. There are 10 of these conveyors, ranging from 6 to 10 feet in length.
1	4.5	600	Belted to conveyor, 60 feet long, carrying baskets from packers to pasteurizers.
5	7.5	750	Each motor belted direct to a Ruff pasteurizer. Capacity of each is 25 barrels per hour.
1	7.5	600	Belted to conveyor, 200 feet long, carrying baskets of bottles from pasteurizers to labeling department.
1	4.5	600	Belted to trolley, 250 feet long, carrying empty baskets from labeling machines to packers.
20	0.25	900	Each geared direct to a World labeling machine, labeling nect and body of bottle in one operation. Capacity of each machine, 40 bottles per minute.
4	1	1,800	Each driving elevator for beer cases.
5	0.5	850	Each driving conveyor for cases.
20	1	1,800	Each motor belted to a short conveyor for carrying bdtles from labeling machines to packing cases.

BRICK AND CEMENT MACHINERY.

The art of brick making has been revolutionized in the past twenty years by the introduction of power driven machinery and has attained its proper rank among the large industries. A conservative estimate of the 100 and more varieties of bricks manufactured in the U. S. alone places the aggregate output at more than twenty thousand million per year. The electric motor has been instrumental in attaining this end.

The induction motor in some form is best applicable to this industry. For dry pans, sanders, conveyors, fans, bucket elevators and other machines of similar requirements the standard G. E. Form K motor with short-circuited bar-wound rotor is usually entirely satisfactory. Each of these applications involves continuous duty at constant speed together with relatively easy starting condition and no occasion for reversal of direction of rotation. On the other hand, for pug mills, augers, tempering wheels, hoists, excavating shovels, etc., where frequent starting and reversal, variable speed requirements and excessive starting torque are encountered, a motor similar to the G. E. Form M motor, with phase wound rotor and external secondary resistance is in general recommended.

When direct current apparatus must be used, motors with compound windings should always be employed except for driving fans, for which service shunt motors are suitable. Where the service requirements are similar to those outlined for Form K induction motor, the direct current motor should have the standard amount of series winding; where Form M motors would be suitable

for alternating current service, the direct current motor should have approximately 40% of series winding, and commutator and bearings should be properly protected from grit and flying mud.

The widely separated points of application of power in most brick plants necessitates either several installations of prime mover or an efficient transmission of power. It is in this last case that it shows its great efficiency. In up-to-date plants equipped for electrical operation throughout, a great variety of motor applications is found. The clay or shale is excavated by means of electrically operated shovels and loaded into transfer cars hauled by an electric yard-locomotive to stock piles where, under the action of rain and frost, it is weathered and partially disintegrated. From the stock piles the clays, especially the harder shales, are transferred to the motor-driven roll crushers or dry-pans, and screens, and then by cup conveyors to the pug mill. From the pug mill the now thoroughly mixed and tempered mass is delivered to the auger brick machine where it is forced through dies to produce a true cross section with maximum uniformity of density, in the form of a continuous rectangular column. A frame carrying tightly strung piano wires or suitable knives rotating at the proper speed, cuts the issuing column of clay into standard sized blocks or bricks. The green bricks are carried by a belt conveyor, which moves somewhat faster than the column issuing from the auger and consequently separates the bricks slightly, to the re-presses, where they are forced into molds and subjected to heavy pressure. This operation smoothes the surface, squares up the corners and imprints the maker's

name, etc. The brick is now ready for the drying house and kiln. In addition to the machines mentioned electric motors find a most satisfactory application driving centrifugal or geared pumps for removing excess water from the clay pits and also for driving the large ventilating fans in the drying house.

Accurate figures covering the cost of electrical operation are difficult to obtain owing to the widely varying factors influencing production. Records from several New England plants with a daily capacity of from 50,000 to 100,000 soft-mud sand-moulded bricks, indicate a fair average of 15 to 20 molds of six bricks each per minute or from 90 to 100 bricks per kw-hr. for all electrical power consumed. Plants using the stiff-plastic method show approximately the same output per kw-hr. energy in brick machines proper. One plant of 156,000 daily capacity shows a power consumption of 1740 kw-hr. per day for its auger brick machines. Another plant, with a daily capacity of 200,000 common bricks, shows for two successive months an average monthly output of 4,700,500 bricks at an average expenditure of 45,600 kw-hr. in driving its auger machines. Where the change from steam engine or other form of mechanical power has been made, an estimated saving in operating expense of from 20 to 30% has often been effected. While the total power required, including auxiliary devices, varies from 12 to 18 kw-hr., a conservative estimate of power required by pug mills and augers is about 1.5 h.p. per 1000 bricks, or 11 kw-hr. per 1000 bricks produced.

Brick, cont.

Applications.

1-35 HP	170 RPM	motor	driving	Standard 9' dry pan.
1-25 HP	135 RPM	"	"	Special double shaft pug mill.
1-25 HP	248 RPM	"	"	10' Pug mill.
1-125 HP	165 RPM	"	"	Special giant auger. Cap. 19.5 cu. yd/hr.
1-35 HP		"	"	#1 Giant auger. Av.load 18.5 HP.
1-5 HP		"	"	10", 470'/min. Cup elevator.
1-40 HP		"	"	Drying drum group group.
1-5 HP	1800 RPM	"	geared to	Universal Brick Setting Machine.

CEMENT MANUFACTURE.

There are certain features in the manufacture of Portland cement that differentiate it commercially from almost every other industry. The raw materials underlie more than 20% of the entire area of the United States. Their initial cost is low, the cost of quarrying is slight, and, owing to the eager market, and more particularly to the widespread deposits of raw materials, no successful merger can be formed to regulate the selling price. The price of the finished cement is determined almost entirely by the actual cost of the different operations through which the raw material passes. In view of this fact, it is obvious that the most prosperous companies will be those that adopt, at the outset, the cheapest and most efficient means of operating the various machines necessary in cement manufacture.

The advantage of individual electric drive in machine shops and factories, in eliminating line shafting and adding to flexibility and economy are equally applicable to cement mills. There are, however, certain inherent requirements in the manufacture of cement which completely establish the argument in favor of electric motors for this class of work.

1. Under normal conditions cement mills operate twenty-four hours a day, seven days a week, and the mill must be kept in practically continuous production. The shut down of any one machine, or the failure of its driving power, must not affect the operation of any other machine.

2. The direction and distance of power transmission should not in any way interfere with the most efficient layout of the

plant.

3. In order to keep a check on the cost of manufacture, a continuous and accurate record should be available, showing the amount of power used in each of the different departments. The ease and accuracy with which the power used can be metered and apportioned between the different departments with the electrical system is an advantage of which the cement engineer makes frequent use in locating trouble and reducing cost. Data obtained by the use of indicators with mechanically driven plants are liable to be inaccurate and lead to erroneous conclusions, because of the difficulty of taking cards often enough, and over periods long enough to show the true load curve. This point is illustrated in Fig. 3. Curve A shows the apparent load curve obtained on a plant by taking hourly readings of the indicating wattmeter. The average of these readings, B, is 1675 kw., which is the apparent power required to operate the mill. The actual average power, however, required on the day of the test, as determined from the recording wattmeter C, was only 1554 kw., or 7% less than would be concluded from the hourly readings alone. It is practically impossible with engine driven plants to obtain more accurate data than those represented by curve A, and it is evident that conclusions as to the actual cost per HP, or the power used in a certain operation, might be very misleading if based on such readings. Curve drawing and integrating meters, however, give the engineer of an electrically driven plant an absolute check on both operation and cost.

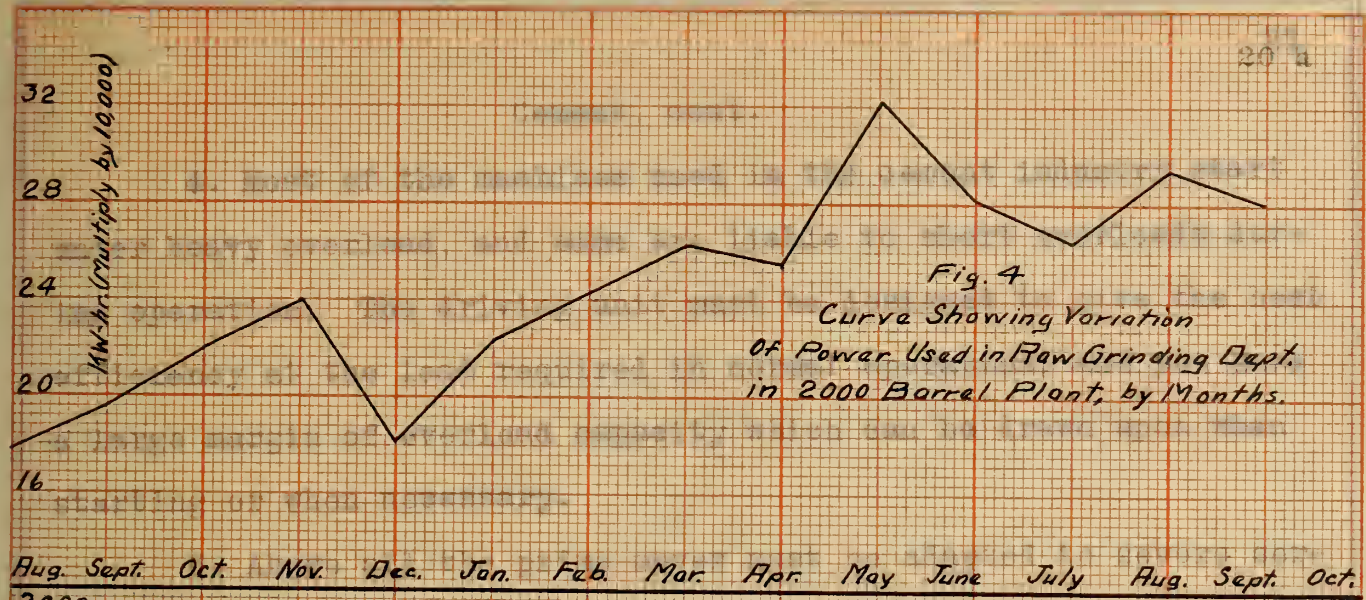


Fig. 4
Curve Showing Variation
Of Power Used in Raw Grinding Dept.
in 2000 Barrel Plant, by Months.

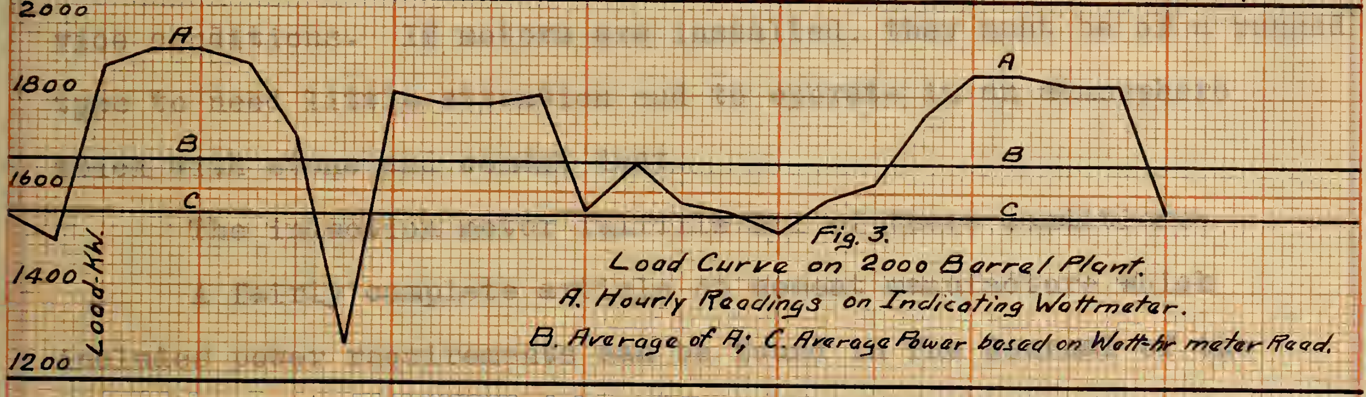


Fig. 3.
Load Curve on 2000 Barrel Plant.
A. Hourly Readings on Indicating Wattmeter.
B. Average of A; C. Average Power based on Watt-hr meter Read.

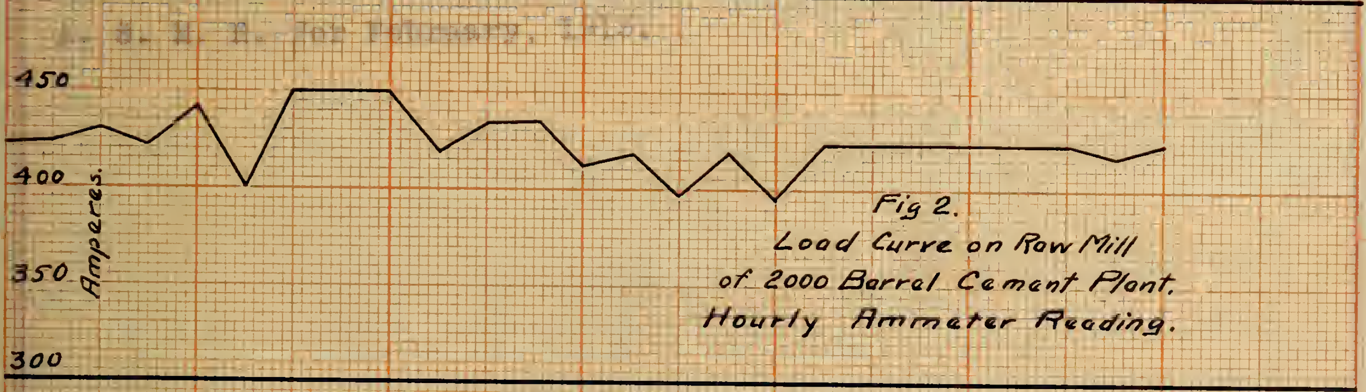


Fig 2.
Load Curve on Raw Mill
of 2000 Barrel Cement Plant.
Hourly Ammeter Reading.

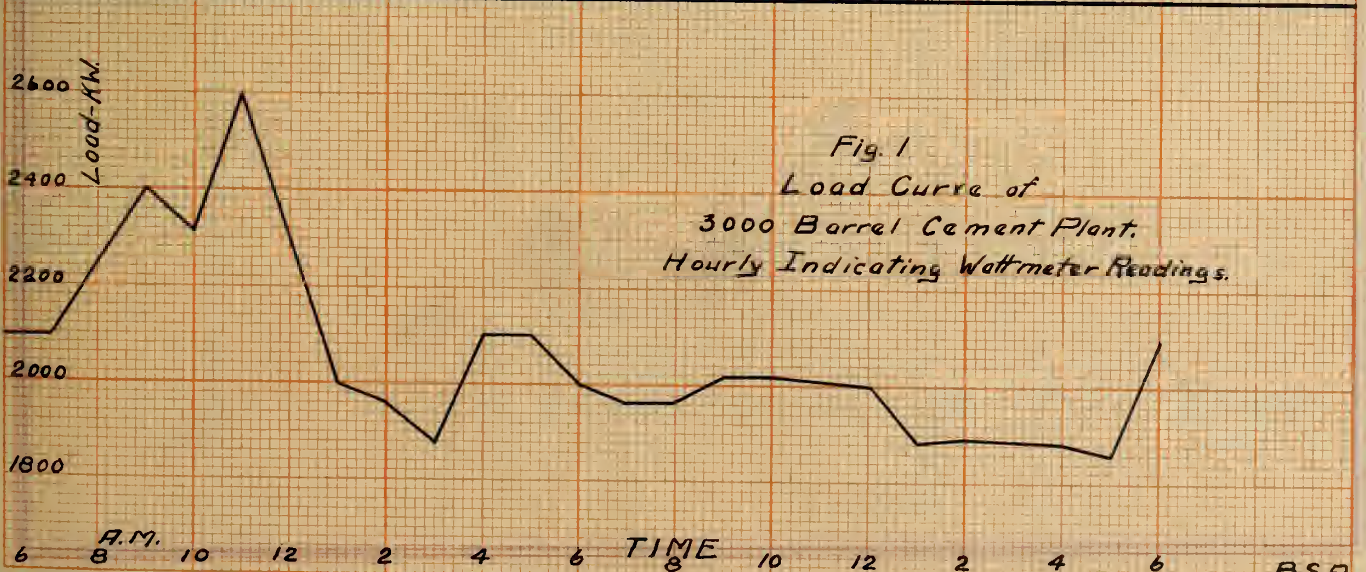


Fig. 1
Load Curve of
3000 Barrel Cement Plant.
Hourly Indicating Wattmeter Readings.

B.S.P.

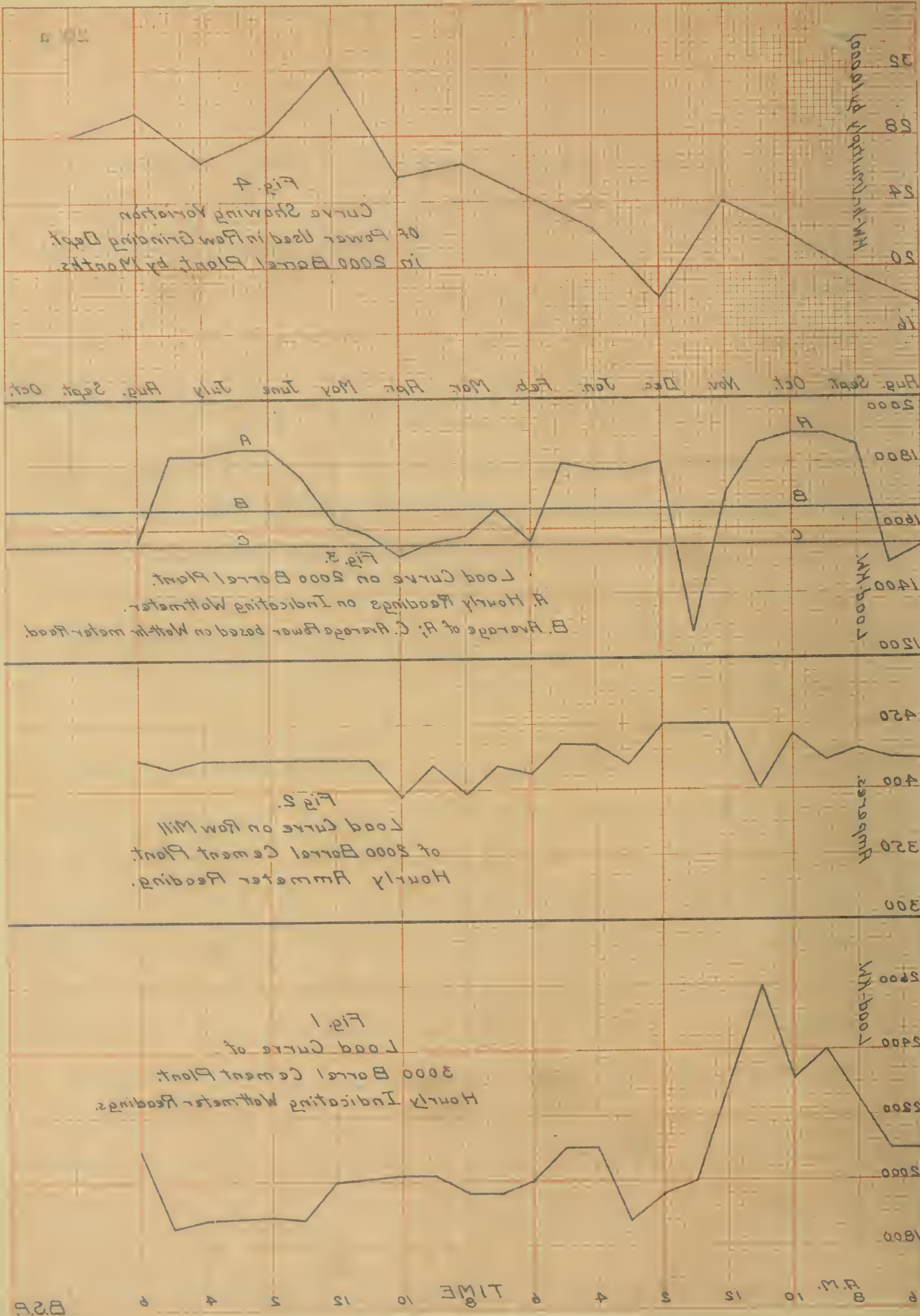


Fig. 4
Curve Showing Variation
of Power Used in Raw Grinding Dept.
in 2000 Barrel Plant by Months.

Fig. 3.
Load Curve on 2000 Barrel Plant.
A. Hourly Readings on Indicating Wattmeter.
B. Average of A; C. Average Power based on Watt-hr. meter Read.

Fig. 2.
Load Curve on Raw Mill
of 2000 Barrel Cement Plant.
Hourly Ammeter Reading.

Fig. 1
Load Curve of
3000 Barrel Cement Plant.
Hourly Indicating Wattmeter Readings.

Cement, cont.

4. Most of the machines used in the cement industry start under heavy overload, and some are liable to short overloads during operation. The driving unit must be designed to give the best efficiency at the load required in normal operation, and yet have a large margin of overload capacity which can be drawn upon when starting or when necessary.

5. Above all the prime mover must be adapted to severe service conditions. If motors are installed, they must be of a rugged type to need little attention and to operate in an atmosphere thick with stone and cement dust.

The induction motor fulfills all of these conditions.

A fairly complete article on cement manufacture which includes power requirements can be found in The Journal of the A. S. M. E. for February, 1913.

TABLE OF HORSE-POWER, OUTPUT AND SPEED

For some of the figures contained in the following table, we are indebted to Mr. Richard K. Meade's treatise on Portland Cement.

Type	Size	H.P. to Drive	Revs. per minute: Pulley	Revs. per minute: Main Shaft	Output in tons per hour: Hard Lime	Cmt. Rock	Marl Clay	Clinker	Coal
Gyratory Crusher*	5D	25-40	400-450	200	20-30	25-35			
Gyratory Crusher*	6D	30-60	400-450	200	30-40	30-50			
Ball Mill †	7	30-40	125	21-23	3-5	4-6		2½-3	
Ball Mill †	8	40-50	125	21-23	4-7	5-8		3½-5	
Tube Mill †	5'x22'	70-80	180	21-27	3-4	4-6	8-12	2½-3	2
Tube Mill †	5½'x20'	80-90	180	21-27	4-6	5-8	10-15	3-4	2½
Kominuter †	No. 66	40-55	160-175		5-7	6-8		5½-7	
Griffin Mill ‡	30"	25-28	190-200	190-200	1½-2½	2-3		2-3	1½-2
Griffin Mill ‡	36"	30-35	135-150	135-150					
Griffin 3 Roll ‡	30"	40	150	150	4-5	5-6			4-6
Fuller Lehigh Mill ‡		30-50	210	210	3-3½	3½-4			2¼
Kent Mill ‡		25-30	180-220	180-220	3-4	3½-4		3½-4	3-4

Type	Length	H.P. to Drive	Revs. Per Min	Output in Barrels Per Day
Rotary Kiln †	60ft.	10-15	1-3	250
Rotary Kiln †	80ft.	10-15	1-3	300
Rotary Kiln †	100ft.	15-20	1-2	450
Rotary Kiln †	120ft.	15-25	1-2	580
Rotary Kiln †	150ft.	20-25	½-1	740
Rotary Kiln †	170ft.	20-30	½-1	860

*Starts light when empty; overload torque at starting if hopper contains rock.
†Take more than mornal torque for starting.
‡Starts light.

CEMENT MANUFACTURE
Applications.

1-150 HP motor belted to	# 7-1/2 AUSTIN gyratory crusher, Cap. 75-100 tons hr.	
1-100 HP " " "	5.5' x 22' Tube mills.	
1-150 HP " " "	#18 Smidth Tube Mills.	Lenix belt drive.
1-75 HP " " "	#66 Smidth Kominuter.	" " "
1- 5 HP " " "	Cement sacking machine	
1-40 HP " " "	36" Cornish rolls for crushing cement clinker.	
1- 40 HP " " "	Pick pivoted bucket conveyor.	
1- 40 HP " " "	Coal feed for kilns and blower for clinker cooler.	
1 -20 HP " " "	Aero coal pulverizer to supply Rotary kilns.	

ELEVATORS, MINING & HOISTING MACHINERY.

This is a very important field for the application of electric power. In all forms of hoisting, reliability is a necessary factor and the modern motor fulfills that specification. Control is another item that has a great deal to do with this sort of machinery and the simplicity of electric control is very often a deciding feature. It will not be attempted to keep the different divisions of this section entirely separate as they are so closely related that it would entail a series of repetitions. However, it will be handled so as to cover the ground as completely as possible.

Elevators.

The first application of the electric motor to elevator service was in connection with the ordinary type of belt driven machine, by employing a non-reversible motor for driving the line shaft to which the elevator was belted. Since the motor could not be reversed, the elevator was controlled by shifting the open and closed belts.

By using a reversible motor, two belts are not necessary, and all that is required is a single belt between the countershaft and the machine, running on tight and loose pulleys.

The next step in the development of the electric elevator was the direct connection of the motor to the shaft of the machine.

In elevator service the motor is required to start under full load and be able to speed up rapidly. The first condition that of starting at full load is met by the use of a D.C. cumulative compound wound motor - the series field giving the high

starting torque and the shunt winding steadying the field. The second condition, that of speeding up is brought about by the controlling device.

The controlling devices of an electric drum elevator consist of the following separate mechanisms: (1) controller; (2) brake; (3) operating mechanism. The controller in addition to starting and stopping the motor and bringing it up to speed, must at the same time gradually cut out the series winding so that the motor operates entirely on the shunt winding when normal speed is reached. The type of controlling device now used considerably is the "magnet control system". The function of the brake is to insure a safe and gradual stoppage of the car. Both band and block brakes are used and are always located near the motor on the worm shaft. The function of the operating mechanism is to afford a ready means of operating the controller from the car. This may be done by either mechanical or electrical means, the latter being used to some extent with the "magnet control system". In 1897 Mr. A. L. Duevelius patented an elevator using a slow speed electric motor direct connected to the driving sheave, and in this form it is now used for high lifts and high speeds. The ropes from the car pass over the driving sheave, thence under an idler and again over the driver and then down to the counterbalance. The speed of the car is practically that of the driving sheave. The gearless traction type of elevator is considered much safer than other types for the following reasons:- (1) More hoisting ropes may be used thus reducing the danger of a free fall due to the simultaneous failing of the ropes. (2) The tractive force becomes practically nothing

Elevators, cont.

when the counterbalance or the car rest on the buffers at the bottom of the shaft, thus preventing overwinding since the motor may continue to run without causing the car to move. These buffers serve as limit stops. In addition to the above advantages, the height of lift is unlimited and very high speeds are possible.

Among the latest installations of this type are those in the new Singer Building and the tower of the Metropolitan Life Insurance Building of New York, and in both of these the apparatus is located above the elevator shaft.

Applications.

1- 30 HP 500-900 RPM motor driving worm gear passenger elevator made by Marshall Bros., Pittsburg, Cap. 2500 # at 200' per min.

1- 25 HP 450-900 RPM motor driving Tandem Traction Type Elevator made by Kaestner & Hecht, Chicago, Cap. 2500 # at 350' per min.

1- 20 HP 725 RPM motor driving Passenger elevator made by Albro-Clem Elevator Co., Philadelphia, Cap. 2000 # at 140' per min.

1- 60 HP 600-1200 RPM motor driving Passenger elevators made by Van Emon Elevator Co., San Francisco, Cap. 2500 # at 600' per min.

1- 20 HP 450-900 RPM motor driving High Speed,Geared,Traction Type Pass. Elev. made by Van Emon Elevator Co., Cap. 3000 # at 200' per min.

1- 38 HP 450-900 RPM motor driving Pass. Elev. made by Haughton Elevator Co., Toledo, O., Cap. 5000 # at 300' per min.

Applications, cont.

1- 11 HP 720 RPM motor driving Freight Elev. made by Salem Elev. Works, Salem, Mass., Cap. 4000 # at 50' per min.

1- 40 HP 690 RPM motor driving Tandem Gear Elev., made by Haughton Elevator Co., Toledo, O., Cap. 4000 # at 200' per min.

1- 15 HP 850 RPM motor geared to Pass. Elev. made by Nat'l Elev. & Machine Co., Honesdale, Pa., Cap. 1500 # at 200' or 3000# at 100' per min.

1- 50 HP 450-900 motor driving Tandem Gear, High Speed Pass. Elev. made by Kimball Bros., Council Bluffs, Ia., Cap. 4500 # at 275' per min.

1- 10 HP 850 RPM motor driving Internal Geared Freight Elevator, made by Albro-Clem Elev. Co., Cap. 3500# at 55' per min.

1-3.5 HP 975 RPM motor chained to Freight Elevator made by Marshall Bros., Pittsburg, Pa., Cap. 1500 # at 50' per min.

1- 18 HP 720 RPM motor driving Freight Elev. made by Reedy Elev. Co., Hoboken, N. J., Cap. 6000 # at 50' per min.

1- 10 HP 650 RPM motor driving Freight Elev. made by J. B. Adt Machine Works, Baltimore, Md., Cap. 3000 # at 60' per min.

1- 15 HP 850 RPM motor driving Pass. Elev. made by Westbrook Elev. Co., Danville, Va., Cap. 2500 # at 100' per min.

Elevators
Applications.

1- 10 HP 790 RPM motor geared to Freight Elev. made by Albro-Clem Elev. Co., Phila., Pa., Capacity 3000# at 75 ft. per min.

1- 7.5HP 850 RPM motor driving Freight Elev. made by Landis Elev. Co., Wichita, Kans., Cap. 3000# at 40 ft. per min.

1-7.5 HP 850 RPM motor chained to Garage Elev. made by Albro-Clem Elev. Co., Phila. Pa., Capacity 4000# at 20 ft. per min.

1- 10 HP 840 RPM motor geared to Freight Elev. made by Standard Mach. Co. Chattanooga, Tenn., Cap. 3000# at 75 ft. per min.

1- x20 HP 840 RPM motor driving Freight Elev. made by Marshall Bros., Pittsburg, Pa., Csp. 6000# at 50 ft. per min.

ELECTRIC ELEVATOR PERFORMANCE

No. Eleva-tors	Avg. Rise in feet	Type of Machine	Type of Control	Load in Pounds	Speed feet per Minute
10	303	(Vertical (Sprague-Pratt	Pilot motor	2500	400
5	189	Sprague-Pratt	Pilot motor	2500	400
6	165	Sprague-Pratt	Pilot motor	2500	450
2	213	Drum	Ward Leonard	2000	400
4	235	(2Duplex (2Drum	Fraser Magnet	2000 2000	500) 350)
3	140	Drum	Magnet	2000	400
3	132	Drum	Magnet	2000	350
3	184	Drum	Magnet	2500	400
1	110	Drum	Magnet	2500	250
2	127	Drum	A B See	2000	200
1	113	Drum	Magnet	1500	275
1	73' 3"	Sprague	-----	2000	275
1	127	Traction	Magnet	3000	500
1	258' 10"	Traction	Magnet	3000	500
1	215	Traction (geared)	Magnet	3000	--
1	154' 7"	Traction	Magnet	3000	--
3	190	Drum	A B See	--	395
4	125	Drum	--	2680	260
8	132	Electric-Hydraulic	--	2800	300
4	134	Electric-Hyraulic	--	2000	600

ELEVATOR NUMBERS

	1,2,5, 6	3	4	7,19, 20	15	8	10,11, 13,14, 16,17	12	23	24
Type..................	Elec. Pass-enger	Elec. Pass-enger and freight	Elec. Pass-enger	Elec. Pass-enger and Frt.	Elec. Pass-enger-and Frt.	Elec. Pass-enger and Frt. safe lift	Elec. Pass-enger and Frt.	Elec. Frt.	Elec. Pass-enger and Frt.	Elec. Pass-enger and Frt.
Normal capacity, lb., exclusive of car....	3250	4200	2500	4750	4750	4750	5000	7500	3000	3000
Maximum capacity, lb., exclusive of car....	3800	5000	3000	5500	5500	6500	5500	8000	3600	3600
Normal speed, ft. per minute, up or down..	300	200	250	150	200	200	100	100	200	300
Motor, hp...........	35	35	16	35	35	35	25	30	2 24	30
Motor, r.p.m........	800	800	800	800	800	800	690	460	800	800
Total. car travel...	65 ft. 3 in.	37 ft. $9\frac{1}{2}$ in.	19 ft. $9\frac{1}{2}$ in.	86 ft. $9\frac{1}{2}$ in.	86 ft. $9\frac{1}{2}$ in.	86 ft. $9\frac{1}{2}$ in.	19 ft. $9\frac{1}{2}$ in.	19 ft. $9\frac{1}{2}$ in.	32 ft.	50 ft.

Mining.

The use of electricity in mining is not new, as it has been employed to a limited extent for many years, but the rapid extension which has recently characterized its application is due to several causes, the most important of which are as follows:

1st. The specialization of the electrical manufacturing companies' engineers on the power requirements peculiar to mines.

2nd. The growing appreciation by the engineers of the mining companies of the advantages of electrical power and their active co-operation in the solution of problems entailed by special conditions.

3rd. The improved efficiencies of modern electrical machinery in general and the increasing use of alternating current with its greater flexibility in transmission over distances which are beyond the economical limit of direct current distribution.

4th. The exceptional operating economies which have resulted in numerous installations utilizing electric power, even under the severest service conditions, and the attainment in practically every case of an increased output for a given power consumption.

5th. The necessity for development of properties in which the geological conditions were such that the mines could not be economically operated by the older methods, and the continually increasing distances between the working faces and delivery points in mines already in operation which tended to render electric haulage almost imperative.

Advantages.

In an electrically-operated mine or group of mines, a single power plant may be used to supply power for all, thereby obtaining

Advantages, cont.

economies inherent in central station practice by the use of large and highly efficient prime movers and generating units, reducing the cost of supervision and maintenance and insuring a continuity of service by being able to carry temporary overloads on a portion of the generating in the event of injury to or failure of any unit, or by providing a reasonable capacity in generators normally held in reserve for the same purpose.

The use of electricity eliminates the necessity of long lines of steam or air piping, which are expensive to install or maintain and with which the danger of breakdown and the difficulty of obtaining the necessary working pressures increase with every extension of service. For these conditions electricity substitutes a simple and thoroughly flexible system of transmitting power by means of conductors which can be run and rapidly extended to meet changes in the development, which are not affected by temperature variation and are not liable to mechanical injury or to breakdowns due to floods or shifting ground. They can be safely used in places where steam lines would introduce an element of danger, and finally, they can in many instances be run in shafts or bore holes already in use for other purposes without occupying room that could be utilized otherwise.

In view of the fact that the power required by individual motors can be readily measured by instruments temporarily connected into the circuit, it is possible to maintain the machinery in the best operating condition, as any excess power requirement can be detected readily, and any defect in the machinery promptly corrected.

The flexibility of motor drive renders possible the use of portable machinery, and additions to, or changes in the location of, existing machines can easily be made without interfering in any way with operation of the remainder of the plant.

Mining.
Applications.

1- 300 HP 1500 RPM direct con. to 6-stage, 1000 GPM centrifugal pump.
1- 225 HP 65 RPM motor driving single drum (6 ft.) underground hoist.
1- 700 HP 150 RPM " " (rope) 64 ft. sand wheel.
1- 170 HP 300-450 RPM motor geared to 10" Quintuplex pumps with 400' head.
1-1000 HP 720 RPM motor dir. con. to 5000 GPM 6-stage cent. pump with 500' head.
1- 150 HP motor driving cent. pump rated 2000 GPM 125' head.
1- 150 HP 700-1200 RPM motor D.C. to 4-stage 10" cent. 330' head, 1000 GPM.
1- 75 KV-A 1200 RPM syn. motor driving 1200 GPM, 2-stage cent. against 160' head.
1- 100 HP 750 RPM motors driving 5000 GPM 1-stage cent. pumps against 50' head.

2-125 HP geared to 6-ft. hoist drum Load Factor 76%.
2- 88 HP belted to 5-ft. " "
1-175 HP motor geared to Worthington 10" turbine pump.
1-106 HP " driving 14 x 12" triplex pump.
1- 60 HP " belted to 6-wheel single-stage pump.
1- 60 HP " " " 8 x 12" duplex pump.
1- 4 HP " " " 2" Blackmer rotary pump.
1- 5 HP " " " 3" triplex pump.
1- 10 HP " " " 4" Boyts & Porter duplex pump.

1- 10 HP 1040 RPM motor belted to Stine 5 ft. suction fan running at 300 RPM.
2- 20 HP 1040 RPM motor each belted to Stine 6 ft. suction fan running at 300 RPM.

Mining Applications, cont.

1- 20 HP	1040 RPM motor D.C. to Morris #3,4" cent. pump.
1-2.5 HP	1200 RPM motor geared to 3 x 4" x 40-stroke Dean triplex pump.
3- 10 HP	1200 RPM motor each geared to 4 x 6" x 40-stroke Deming triplex pump.
4- 25 HP	Each driving a Morgan-Gardner 6' undercut coal-cutting machine.
1- 25 HP	driving a Sullivan 6' undercut coal-cutting machine.
1- 5 HP	1600 RPM motor belted to #77 Ingersoll-Rand air comp. Air at 95# .

Hoisting Machinery.

Applications.

Crocker-Wheeler electric hoists.

Hoist No.	Motor	Drum Diam.	Drum length	Av.Rope Speed	Weight of load.
7-1/2	7-1/2	9"	16"	125	1300 lb.
10	10	10"	16"	150	1600 lb.
15	15	12"	16"	165	2000 lb.
20	20	14"	18"	165	3000 lb.
25	25	14"	18"	175	3200 lb.
35	35	16"	18"	175	4500 lb.

Alternating Current Motor Distribution in Mines

H.P.	Volts	Conn.	Service.
2-75	440	b	Two air compressors
100	440	g	Double-drum hoist
30	440	g	Triplex pump
30	440	g	300 g.p.m. triplex pump
12	440	g	100 g.p.m. triplex pump
#2-400	3300	b	Two 2500 cu.ft.compressors
2-200	440	b	Two 1250 cu.ft.compressors
300	440	g	Four-drum hoist
50	440	d	35 kw.motor-generator set
35	440	b	Gyratory crusher
500	440	g	Double-drum hoist
110	3300	d	75 kw.motor-generator set
50	440	d	35 kw.motor-generator set
5	440	g	Air brake compressor
200	440	b	1250 cu.ft. compressor
35	440	b	Jaw crusher
50	440	d	35 kw.motor-generator exc.
6	440	d	Ventilating fan for 800 kw. turbine

#Synchronous motors d-Direct connected b-Belt connected ~~g-Geared~~

All motors three-phase, 25 cycle.

METAL WORKING MACHINERY.

Perhaps the largest application of motor drive is in the industries using metal working machinery. Although motor drive in machine shops, etc. has been so generally and successfully applied, there is still a considerable field as yet undeveloped. One of the most important phases influencing the successful conduct of any manufacturing establishment is the amount of output obtainable with a given personnel, tool equipment, floor space and working time. Without increasing any of these factors, the substitution of mechanical drive by the installation of electric motors has variously increased the productive capacity of different shops from 5 to 100 per cent. In other words, a greater amount of work is produced per operative machine per day, due to maintenance of speed under varying conditions of load; the ease by which the maximum cutting speed can be sustained throughout a given operation; the advantage gained by permitting better arrangement of machines in regard to natural or artificial lighting facilities, as well as the readier access to and sequence of material from the unfinished to the finished state. Finally because the greater cleanliness, purer air and generally better hygienic surroundings of the motor driven shop react favorably upon the health, cheerfulness and activity of the operatives.

The accompanying figures 1 and 2 show graphically the saving made in power by the use of electric drive over the use of belting and shafting. They are both diagrams showing the losses in power transmission in the factory of Central Stamping Co., Newark, N. J.

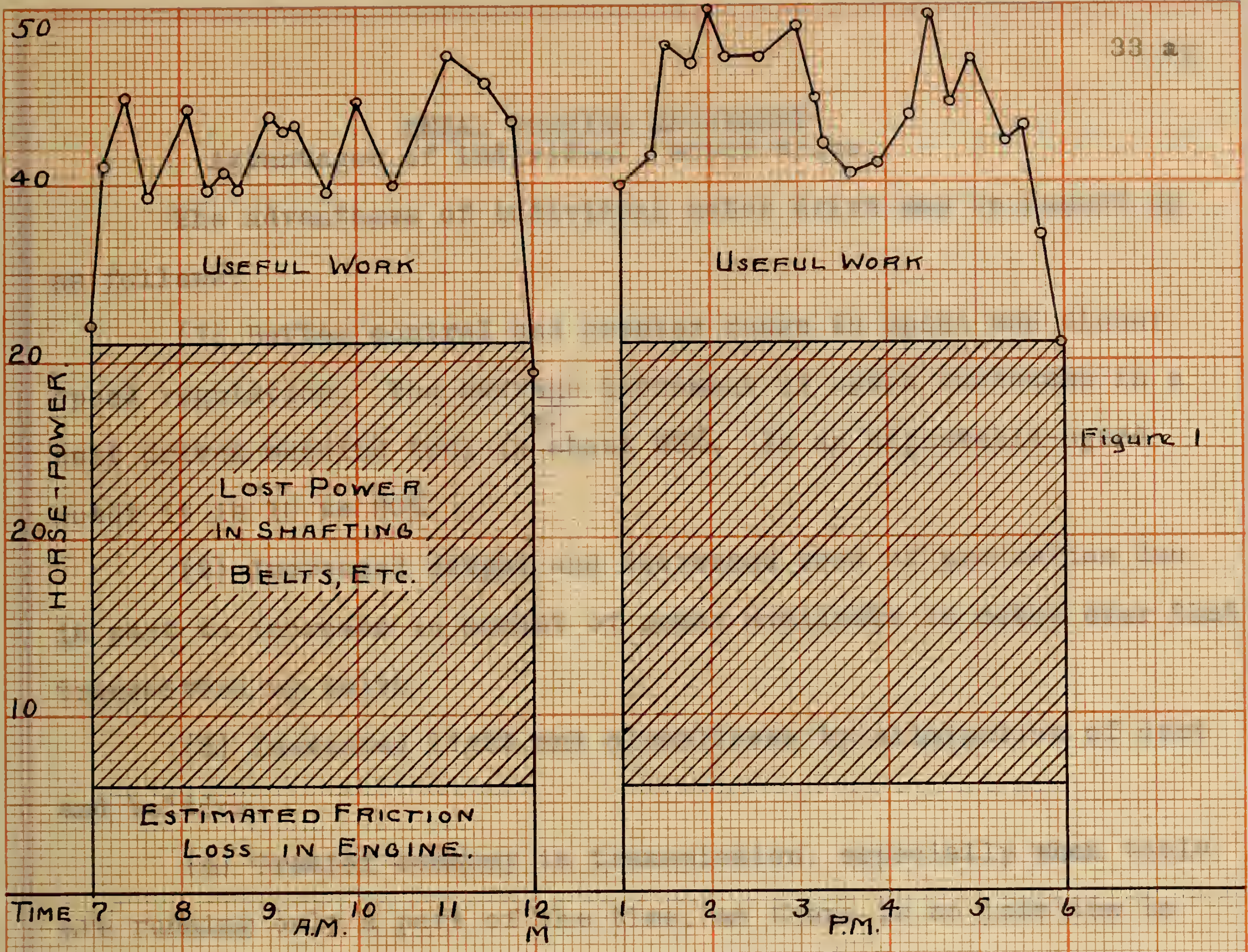


Figure 1

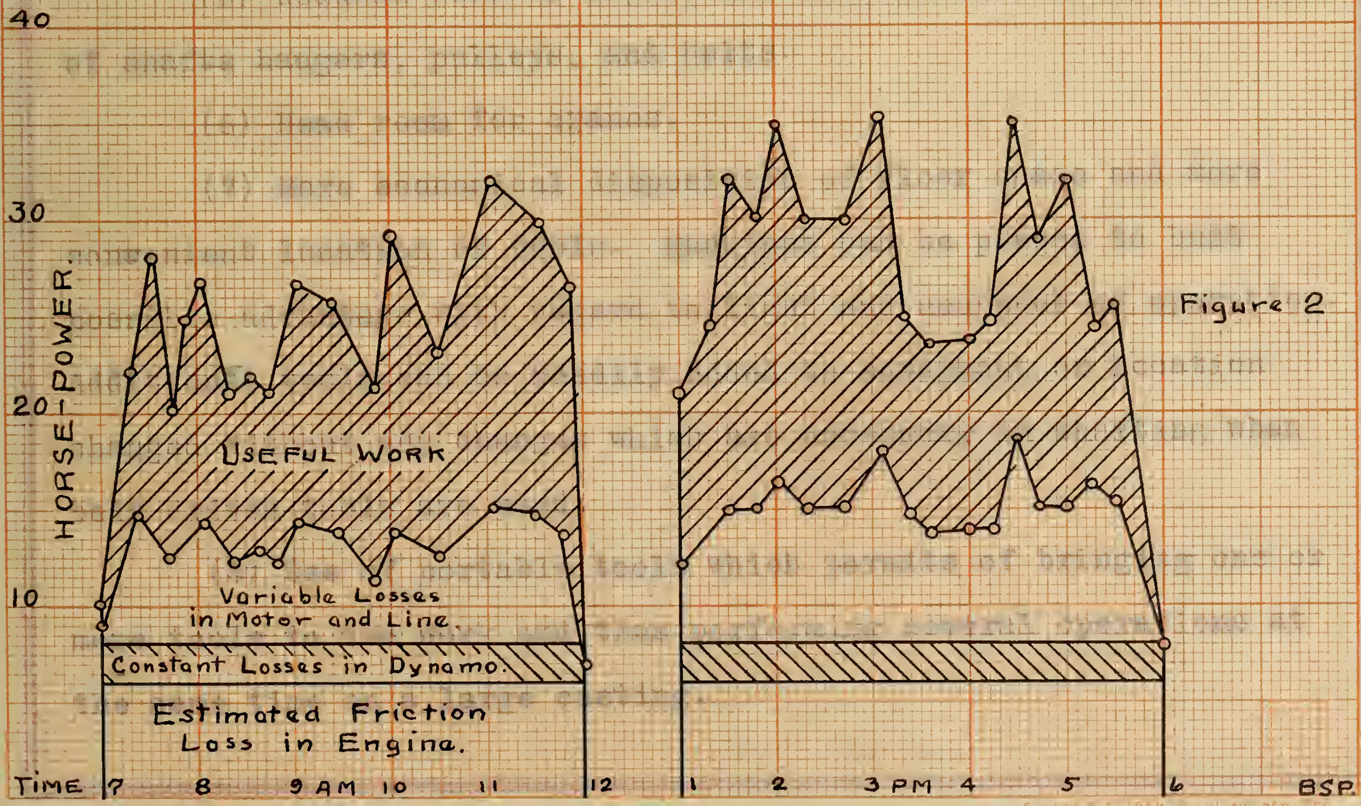


Figure 2

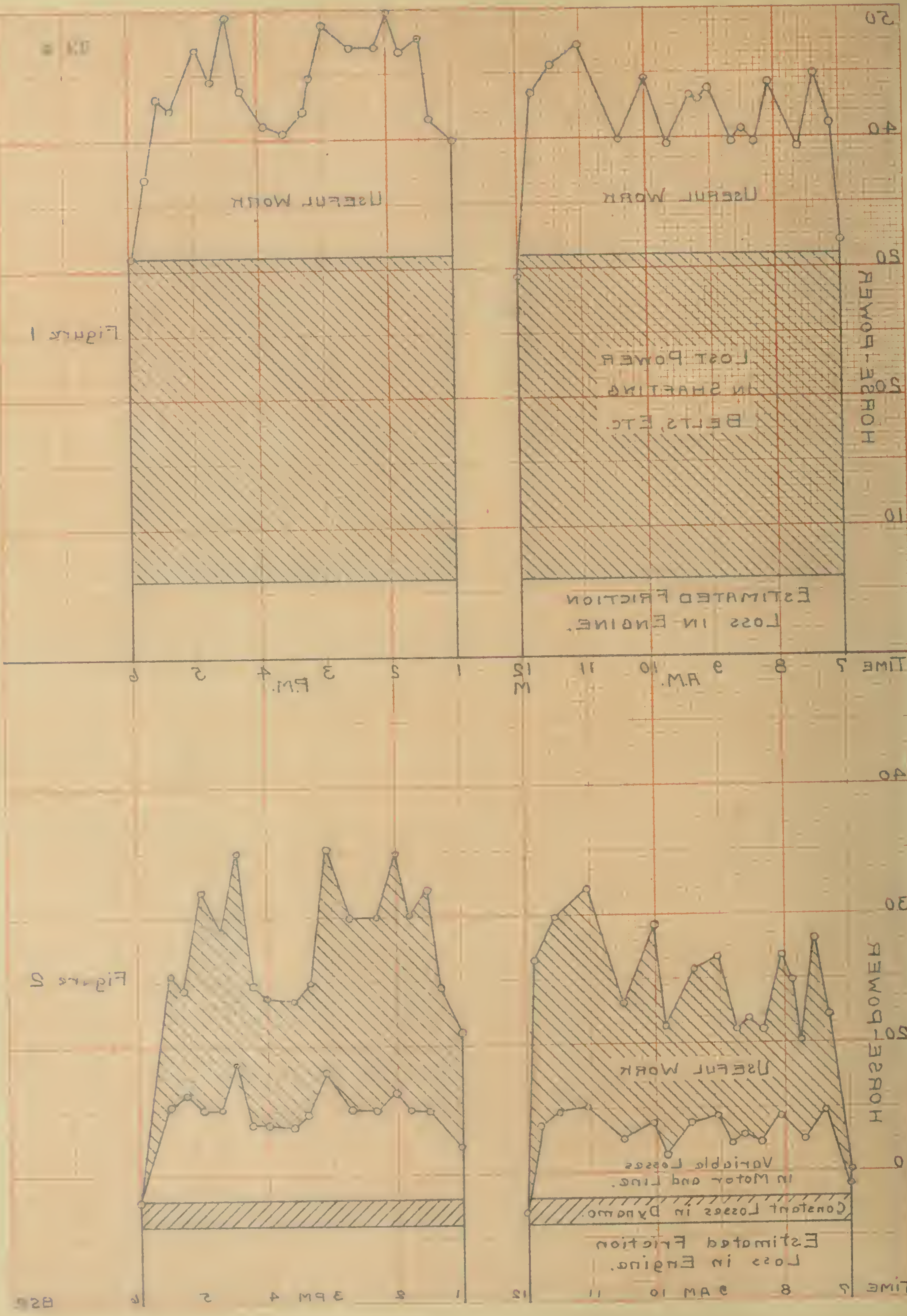


Figure 1
Useful Work
Useful Work
Lost Power in Shafting Belts, Etc.
Estimated Friction Loss in Engine.
Horse-power
50
40
30
20
10
Time 7 8 9 10 11 12 M 1 2 3 4 5 6
A.M.
P.M.
Figure 2
Useful Work
Variable Losses in Motor and Line.
Constant Losses in Dynamo.
Estimated Friction Loss in Engine.
Horse-power
40
30
20
10
Time 7 8 9 AM 10 11 12 1 2 3 PM 4 5 6

METAL WORKING MACHINERY

Advantages of individual motor drive.

The advantages of individual motor drive may be summed up as follows:

(1) Better control and greater range in speed and closer speed regulation. The average increment of speed increases in a belt driven machine tool is about 50%. In an adjustable-speed motor it is 10 to 20%.

(2) Increased output and decreased cost of production due in part to increase in amount of power available in motor over that transmitted by belts.

(3) Increased light and cleanliness by elimination of dust and belting.

(4) Greater economy in transmission, especially when tools are running only a part of the time, as there is no loss due to driving belts and shafting when tool is idle.

(5) Reduced cost of repair and maintenance, owing to absence of shafts hangers, pulleys, and belts.

(6) Head room for cranes.

(7) More economical disposition of floor space and more convenient location of tools. Machines can be placed to best possible advantage with regard to light and sequence of operation Additional tools can be readily added to equipment or location changed without any changes which are necessary in shafting when belt driven tools are used.

(8) Use of portable tools which permits of bringing one or more tools to the work and thus performing several operations at the same time on a large casting.

(9) Reduced cost of building as absence of shafting simplifies construction.

(10) Reduced cost of installation in many cases, especially for tools in isolated positions where expensive shafting and hangers would exceed cost of applying individual motors.

(11) Greater reliability and steadiness of power of freedom from stoppage of a number of tools as in the case of a hot bearing or broken belt.

Metal Working Machinery.

Tests with Belt-reversing and Motor-reversing Planers.

Machine Type	Machine Size	Type Drive	Hp Motor	Input Amp.	Cut In	Stroke	Cutting ft/min	Cutting Time sec.	Return ft/min	Return Time sec.	Cut Total cycle sec.
Planer	36"x10'	Belt	10	33	3/8x1/16	8'6"	28.3	16	72.8	7	25
"	"	Rev'g	10	51	"	"	53.2	9.6	91	5.6	15.4
"	"	Belt	10	38.5	1/2x1/16	"	28	18.2	72.8	7	25.2
"	"	Rev'g	10	56	"	"	53.2	9.7	91	5.6	15.3
Planer	72"x22"	Belt	40	95	1x1/16	10'1"	17.1	35.4	59.3	10.2	45.6
"	"	Rev'g	35	120	"	"	34.4	17.6	73.6	8.2	25.8

The foregoing test shows comparatively what has been accomplished with this type of motor drive. As a general proposition, the saving arising from applying power direct to machine tools is considered the amount of friction load which has thus been eliminated. This often reaches as much as 50% yet is in reality only a small part of what may be saved, as proved by numerous tests. The salient operating features claimed by the manufacturer for the reversing adjustable-speed direct-connected motor drive are: maximum cutting speed sustained uniformly, affording greatly increased production; rapid accelleration on return stroke; reverses very close to a line at the end of a cut; very economical

operation and upkeep; any speed desired within a ratio of four to one; many speed combinations, allowing the slowest cutting and highest return speed to be combined; freedom from shocks, permitting the quickest reversals possible without jar; quiet operation; sparkless commutation;and positive and safe control within easy reach of the operator.

METAL WORKING MACHINERY.
Power requirements.

The following empirical formulae were taken from an article by J. M. Barr, Elect. Jour., Vol. II, p. 11 (1905).

The power required by <u>Engine lathes</u>, using one cutting tool of water-hardened steel at a cutting speed of about 20' per min., is

$$P = 0.15\ R - 1, \text{ in hp.,}$$

where R is the swing of the lathe in inches.

<u>Heavy engine lathes</u>, such as forge lathes require

$$P = 0.234\ R - 2, \text{ in hp.,}$$

The power required by <u>standard Boring mills</u> (R 30") using one cutting tool of water-hardened steel at a cutting speed of about 20'/min. is

$$P = 0.25\ R - 4, \text{ in hp.,}$$

where R is the swing of the mill in inches.

The power required by <u>standard Milling machines</u> using water-hardened cutters running at about 20'/min., is

$$P = 0.3\ L, \text{ in hp.,}$$

where L is the distance between housings in inches.

The power required by <u>standard Drill presses</u> using water-hardened steel drills running at a peripheral speed of approximately 20'/min., is

$$P = 0.06\ R$$

For <u>heavy radial-drill presses</u>

$$P = 0.1\ R$$

where R is the capacity of the drill in inches.

The power required by <u>standard Planers</u> using water-hardened steel at cutting speeds of about 20'/min., return speed about 60'/min., is

$$P = 3\ L.$$

For heavy forge planers

$$P = 4.92\ L$$

where L is the width in feet between housings.

Average practice for Normal crank slotters using water-hardened steels, cutting speeds from 15 to 20'/min., is

Stroke in inches	10	18	30
Horse-power	5	7	10

Shapers using water-hardened steels, at cutting speeds of from 15-20'/min.,

Stroke in inches	16	18	24	30
Horse-power	3	3.5	5	6.5

Operating Speeds of Various Machines Tools.

Saws, band (hot iron and steel)	200-300'/min.	at rim.
Grindstones	800'/min.	at rim.
Emery wheels	5000'/min.	at rim.
Drills for wrought iron	12'/min.	outer edge.
Drills for cast iron	8'/min.	" "
Milling cutters for brass	120'/min.	" "
Milling cutters for cast iron	60'/min.	" "
Milling cutters for wrought iron	50'/min.	" "
Milling cutters for wrought steel	35'/min.	" "
Screw cutting (gun metal, etc.)	30'/min.	at circum.
Screw cutting (steel)	8'/min.	" "
Boring (cast iron)	10'/min.	" "
Sawing (brass)	70'/min.	" "
Sawing (gun-metal)	30'/min.	" "
Sawing (steel)	25'/min.	" "
Sawing (wrought iron)	30'/min.	" "
Sawing (cast iron)	20'/min.	" "

Metal Working Machinery.
Power requirements. Tests.

Power required by Portable Armature Drills.
(Andrew Stewart, before Glasgow Techn. College Sc. Soc.)

Size of Tool	Spindle rev.per min.	Wt.of tool lb.	Diam. hole, in.	Depth hole, in.	Time, sec.	Metal	Watts	Watts per lb. metal per minute.
Breast	800	13	3/8	1.5	65	C.I.	305	7200
1 M 1	450	17	1/2	1.0	120	C.I.	330	4230
1 M 2	250	30	5/8	0.5	40	steel	495	8448
1 M 2	250	30	7/8	1.5	70	C.I.	660	3300
1 M 3	150	32	1	1.5	120	C.I.	550	3666
1 M 3	150	32	1	0.5	80	steel	495	6447
1 M 3	150	32	1-1/4	1.5	180	C.I.	440	4125
1 M 4	100	52	2	1.5	180	C.I.	990	2564
3 M 3	150	48	1-1/4	1.5	120	C.I.	770	3200
3 M 4	100	58	1-1/4	2.75	105	C.I.	1320	2620
3 M 4	100	58	1-3/4	3.0	240	C.I.	1540	3286
3 M 4	100	58	2	2.0	150	C.I.	1880	2940
3 M 4	100	58	2-15/64	2.75	240	C.I.	2200	3040
3 M 4	100	58	2	1.3	150	Mild steel	1860	4650

Power requirements. (Tests).

Lathes.

1- 1.5 HP driving Jones & Lamson standard 2" x 24" flat turret lathe.

1- 2	HP	"	Hendey Norton, 16" engine lathe.
1- 2.1	HP	"	Putnam 18" x 16' engine lathe.
1- 10	HP	"	Pond 36" x 10' engine lathe.

1- 2	HP	motor	driving	20" x 10' Engine medium (Estimated).
1- 2	HP	"	"	18" x 10' " "
1- 2	HP	"	"	16" x 8' " "
1- 3	HP	"	"	2" x 24' Flat turret.
1- 3	HP	"	"	21" heavy screw machine.
1- 1	HP	"	"	20" Universal monitor for brass.
1- 2	HP	"	"	18" " " " "
1 -2	HP	"	"	16" Fox lathe with turret.
1- 2	HP	"	"	12" Speed lathe.
1-7.5	HP	"	"	90" driving wheel, lathe.
1-7.5	HP	"	"	80" " " lathe.
1- 5	HP	"	"	42" truck wheel tire turning.
1- 5	HP	"	"	Axle heavy for drivers.
1- 5	HP	"	"	Axle, double head.
1- 5	HP	"	"	48" x 14' Engine heavy.
1- 3	HP	"	"	36" x 16' " "
1- 3	HP	"	"	30" x 12' " "
1- 2	HP	"	"	28" x 12' " "
1-2.5	HP	"	"	26" x 8' " very heavy.
1-7.5	HP	"	"	88" Wheel lathe.
1- 5	HP	"	"	72" " "

Power requirements (Tests)

Lathes, cont.

1-2 HP	motor driving	Single head axle.	
1-5 HP	"	"	Double " "
1-4 HP	"	"	36" x 16'
1-3 HP	"	"	33" x 18'
1-3 HP	"	"	30" x 12'
1-3 HP	"	"	24" x 16' lathe.
1-3 HP	"	"	42" x 14' "
1-2 HP	"	"	28" x 12' "
1-7.5 HP	"	"	38" x 44' Shaft lathe.
1-10 HP	"	"	62" x 30' Putnam lathe.
1-7.5 HP	"	"	36" x 25' " "
1-6 HP	"	"	90" Driving wheel lathe.
1-5 HP	"	"	48" Lathe.
1-5 HP	"	"	22" Shaft lathe.
1-4 HP	"	"	32" Lathe.

Planers.

1- 30 HP	motor	belted to	10 x 10 x 20 Niles planer.
1- 25 HP	"	"	" 8 x 8 x 20 Pond "
1- 15 HP	"	"	" 5.5 x 5 x 12 Pond "
1- 3 HP	"	"	" 2.25 x 2.5 x 6 Gray "
1- 20 HP	"	"	" Niles 8' planer.
1- 15 HP	"	driving	36" x 12' Woodward & Powell planer.
1- 10 HP	"	"	30 x 30 x 8 Woodward & Powell planer.
1- 20 HP	"	"	56" x 56" x 12' Gray planer.
1- 15 HP	"	"	42" x 42" x 20' Planer.
1- 5 HP	"	"	Dallrtt & Co., portable deck.

Power requirements, cont.

Planers, cont.

1- 15 HP motor driving 54" planer.
1- 10 HP " " 42" "
1-7.5 HP " " 32" "
1- 15 HP " " 60" x 60" x 25' Pond planer.
1- 5 HP " " 36" x 36" x 10' " "
1-7.5 HP " " 36" x 36" x 10' Planer.
1- 5 HP " " 24" x 24" x 6' Pond planer.
1-7.5 HP " " 48" x 54" x 14' Planer.
1- 10 HP " " 42" x 42" x 16' Planer
1-7.5 HP " " 38" x 38" x 10' "
1- 5 HP " " 30" x 30" x 8' "

Planers (G. A. Gray & Co., Cincinnati, O.)

Size (Spur-geared): 22" 24" 26" 28" 30" 32" 36" Standard.
HP recommended: 2.5 3.5 4 5 6 6
Size: 36" Extra heavy 42" 48" 56" 72" Frog & Switch.
HP: 8 12 15 15 25
Size (Spiral-geared): 30" 38" 48" 60" 72"
HP: 6 8 15 20 25

Shapers.

1- 2 HP motor driving 24" Cincinnati shaper.
1- 3 HP " " 18" " "
1- 5 HP " " 18" Shaper.
1- 3 HP " " 16" Traveling head shaper.
1- 2 HP " " 16" " " "
1- 2 HP " " 16" Shaper.
1- 2 HP " " 14" "

Power requirements, cont.

Shapers, cont.

1- 2 HP motor driving 12" Shaper.

1- 5 HP " " 20 x 6" Richards side planer.

1- 3 HP " " #5 Mills & Merrill key-seater.

1- 5 HP " " Colburn key-seater.

Shapers, "Rockford" Joseph T..Ryerson & Son.

Shaper	HP.	Speed variation	Maximum speed.
14" Single geared	2	5 - 1	1500
16" " "	2	5 - 1	1500
16" Back "	2.5	3 - 1	1500
20" " "	3	3 - 1	1500
24" " "	4	3 - 1	1500

Milling machines.

Kearney & Trecker Co., Milwaukee.

1- 3 HP motor driving #1B,24" table feed, 17" vert.feed, 8" cross feed.

1- 5 HP motor " #2B,30" " " 18" vert. " 10" cross feed.

1-7.5 HP motor " #3B,36" " " 19" " " 12" cross feed.

1- 20 HP motor " #5,20" x 60" Ingersoll heavy duty miller.

1- 10 HP " " #3,14" x 18" " " " "

Boring Mills..

1- 5 HP motor driving, Driving wheel quartering machine.

1- 3 HP " " Rod borer.

1-7.5 HP " " 84" Boring and turning, two heads.

1- 5 HP " " 62" " " " " "

1- 5 HP " " 37" " " " " "

1- 5 HP " " 30" " " "

1-7.5 HP " " Cylinder boring machine.

1- 20 HP " " 10' Pond boring mill.

Power requirements, cont.

Boring mills, cont.

1-7.5 HP	motor	driving	#1 Newton floor boring mill.
1- 15 HP	B	"	7' Betts.
1-7.5 HP	"	"	51" Baush.
1- 5 HP	"	"	Car wheel borer.
1- 5 HP	B	"	80" Boring mill.
1- 5 HP	"	"	39" " "
1- 3 HP	"	"	39" Vert. Boring mill.
1- 5 HP	"	"	36" Car wheel Boring mill.
1-7.5 HP	"	"	8' B.M. with slotter.

Drill Presses.

1- 2 HP	motor	driving	40" Vertical drill press.
1- 2 HP	"	"	4-Spindle Gang " "
1-7.5 HP	"	"	30" Vertical " "
1- 2 HP	"	"	40" " " "
1- 2 HP	"	"	36" " " "
1- 2 HP	"	"	20" " " "
1- 5 HP	"	"	8-Spindle arch-bar drill.
1- 2 HP	"	"	Cotter drilling machine.

Drills, Radial.

1- 5 HP	motor	driving	#6 Baush.
1- 5 HP	"	"	5' Radial drill.
1- 5 HP	"	"	#6 " "
1- 5 HP	"	"	72" " " heavy.
1- 3 HP	"	"	60" " " "
1- 2 HP	"	"	48" " " medium.

Power requirements, cont.

Drills, Multiple.

1- 10 HP motor driving Niles 6-Spindle multiple drill.

Punches.

1- 10 HP	motor	driving	#3 double punch.	
1- 10 HP	"	"	#4 single "	
1- 5 HP	"	"	#2 " "	
1-7.5 HP	"	"	#3 horizontal punch.	
1- 3 HP	"	"	Cincinnati	5/8 x 5/8, 10" & 15" throat.
1- 3 HP	"	"	"	5/8 x 5/8, 12" & 24" "
1- 4 HP	"	"	"	5/8 x 5/8, 36" "
1- 7.5 HP	"	"	"	1" x 1" , 36" "
1- 5 HP	"	"	"	3/4 x 3/4,

Shears.

					Length knives.	Hght. Opening
1- 3 HP	motor	driving	1-1/2" sq.	shear	13"	7"
1- 4 HP	"	"	1-3/4" sq.	"	18"	8"
1- 7 HP	"	"	2" "	"	19"	9"
1- 11 HP	"	"	2-1/2" "	"	22"	10"
1- 13 HP	"	"	3 "	"	26"	10"

1- 7.5 HP " " #3 Lennox Bevel. 1" steel.

1- 7.5 HP " " 3/4" " Rotary splitting (Housing type).

1- 4 HP " " 1/4" " " " (Throat type).

1- 7.5 HP " " Shear & Hot punch. Shear cap. 6" x 1/2" cold spring steel, Punch cap. 1" hole hot spring steel 5" x 1-1/4".

Power requirements, cont.

Shears, cont.

Motor Driven Alligator Shear. Joseph T. Ryerson & Son, Chicago.

Motor Drive

No.	Capacity	Length of knives	Height of Opening	Horse Power Required	Size of Belt	Speed of Pulleys	Cuts per minute.
1M	1 ½" sq.	13 inch.	7 inch.	3	4"	200 R.P.M.	50
2M	1 ¾" sq.	18 inch.	8 inch.	4	6"	182 R.P.M.	45
3M	2" sq.	19. inch.	9 inch.	7	6"	190 R.P.M.	40
4M	2 ½" sq.	22 inch.	10 inch.	11	8"	160 R.P.M.	35
5M	3" sq.	26 inch.	10 inch.	13	8"	190 R.P.M.	30

Slotting machines.

1-7.5 HP motor driving 18" Newton slotter.

1- 5 HP " " 14" " "

1- 3 HP " " 8" " "

1- 4 HP " " 14" " "

1- 4 HP " " 24" " "

1-7.5 HP " " 18" " "

1- 5 HP " " 14" " "

1- 3 HP " " 10" " "

1- 5 HP " " Colburn Keyseater.

Miscellaneous.

1- 5 HP motor driving 10" Jarecki Pipe cutter.

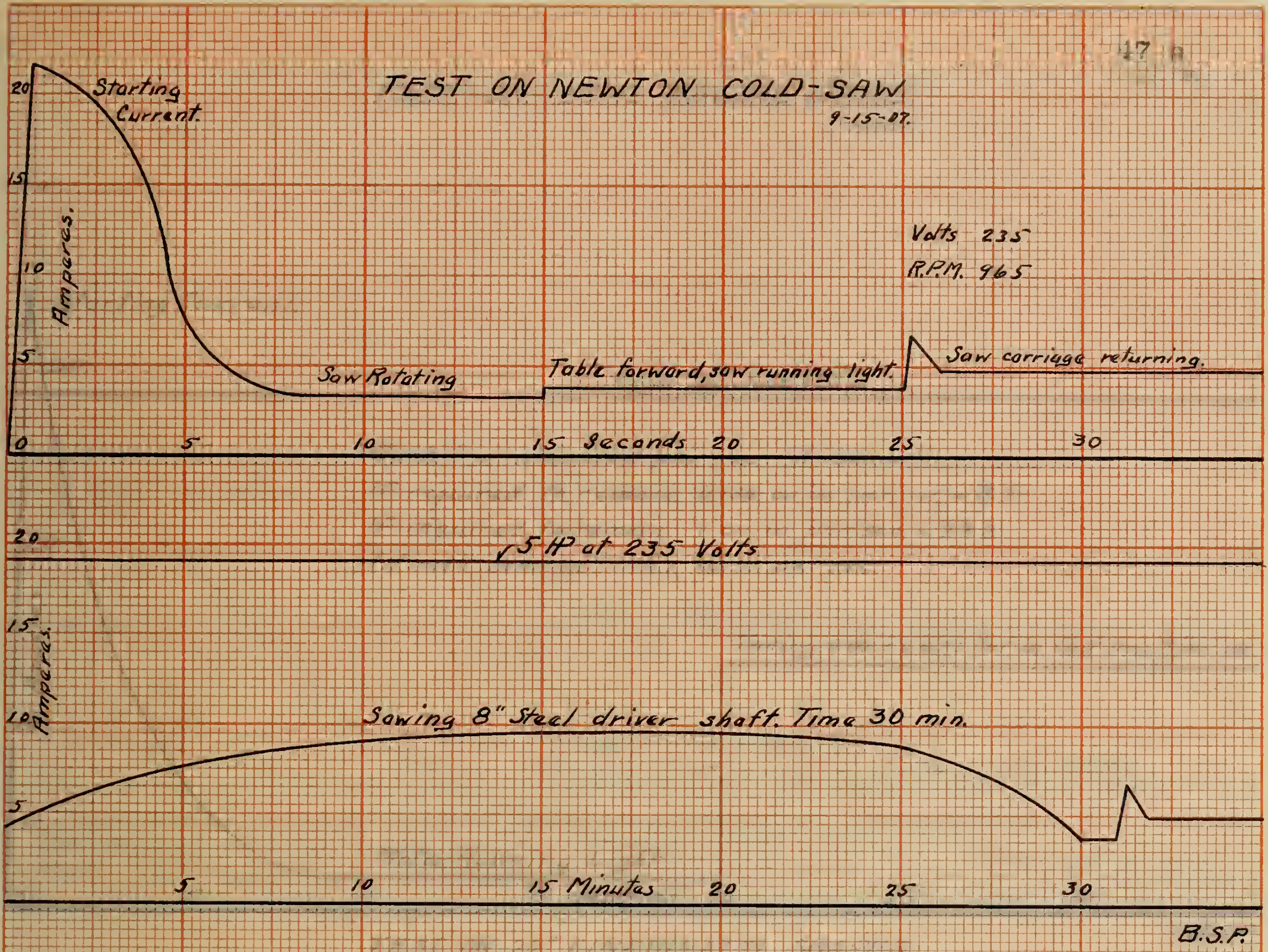
1- 3 HP " " 28" x 5' Spring forming roll and fitting table.

1- 5 HP motor driving Nibbing (cap.1/2") & Trimming (cap. 6" x ¼") machine.

Power requirements, cont.

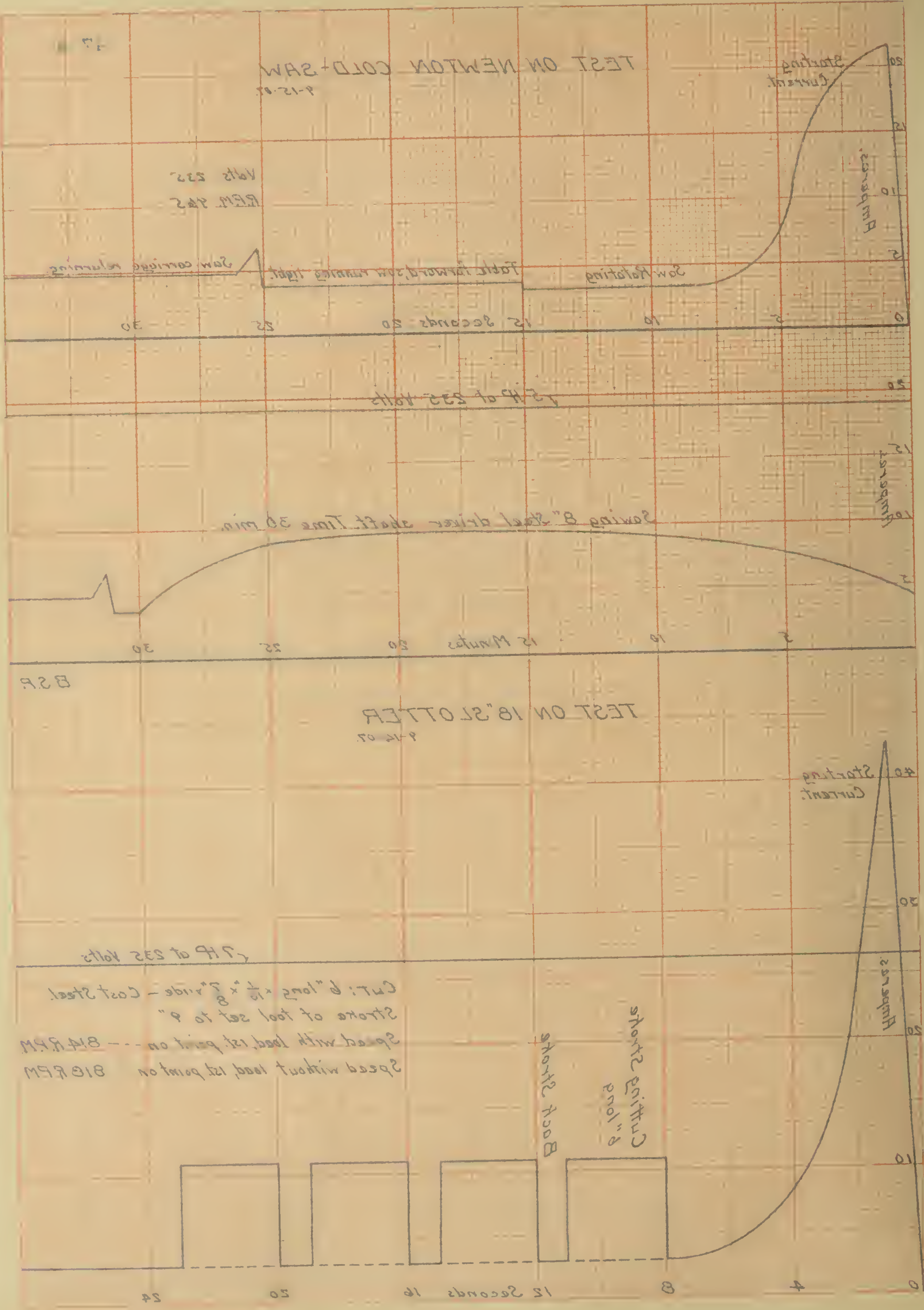
Miscellaneous, cont.

1-7.5 HP	motor driving	Tapering roll & Swegging machine, cap. 6" x 1/2".
1- 2 HP	motor driving	1" double. (Acme Machine Co., Cleveland, O.)
1-2.5 HP	" "	1-1/2" " " " " "
1-7.5 HP	" "	1" Bolt Header.
1- 15 HP	" "	1-1/2" Bolt Header.
1- 10 HP	" "	1-1/2" " " and forger.
1- 3 HP	" "	Corrugating machine.
1- 30 HP	" "	5" Upsetting machine.
1- 15 HP	" "	Open die rivet and track bolt machine. (Acme Co.)
1- 52 HP	motor driving	High speed friction saw, cap. 15", 80# beams.
1- 15 HP	motor driving	30" Vertical grinder.
1- 7 HP	" "	#2 Taylor Universal tool grinder.
1- 5 HP	" "	Automatic screw machine.

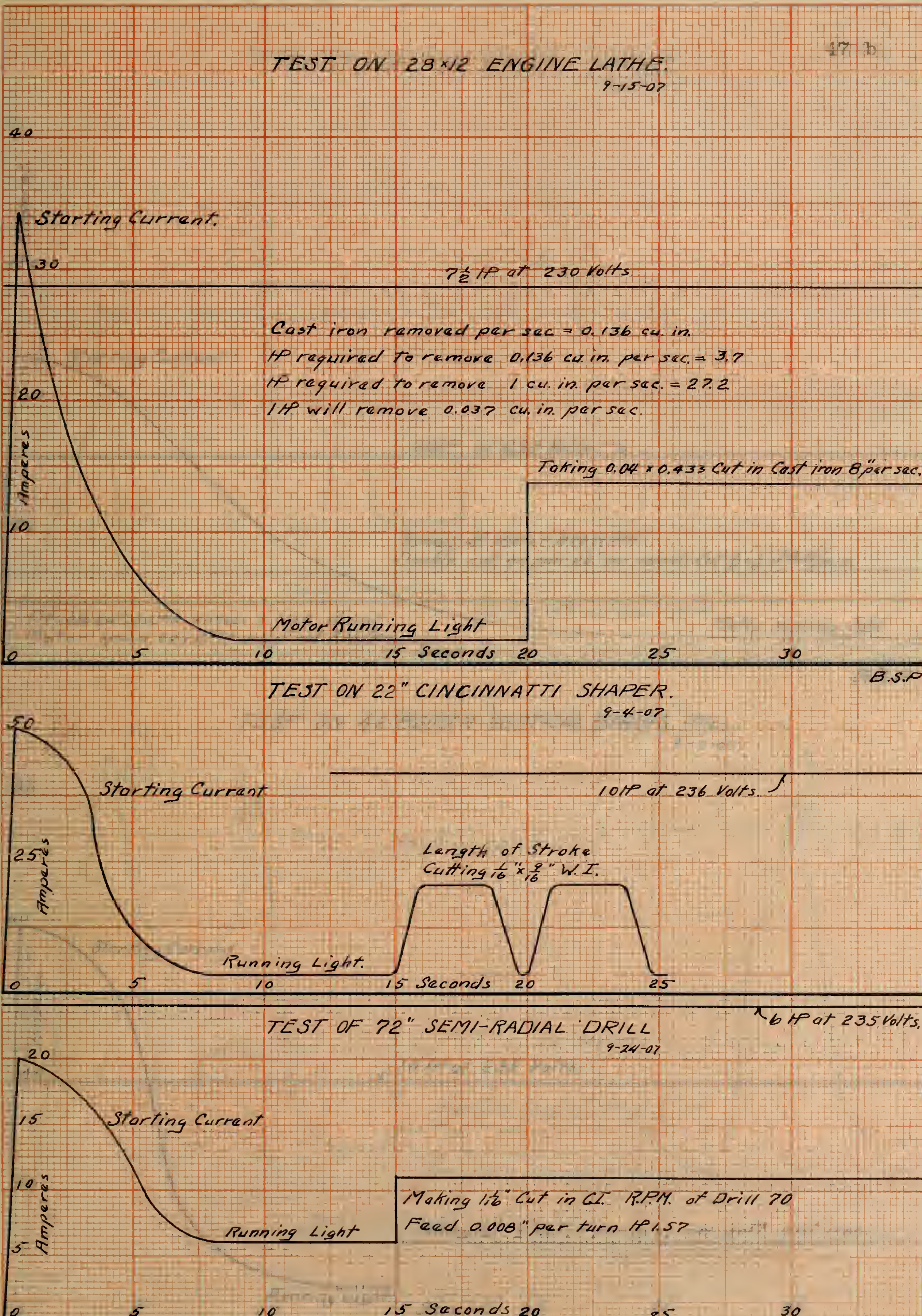


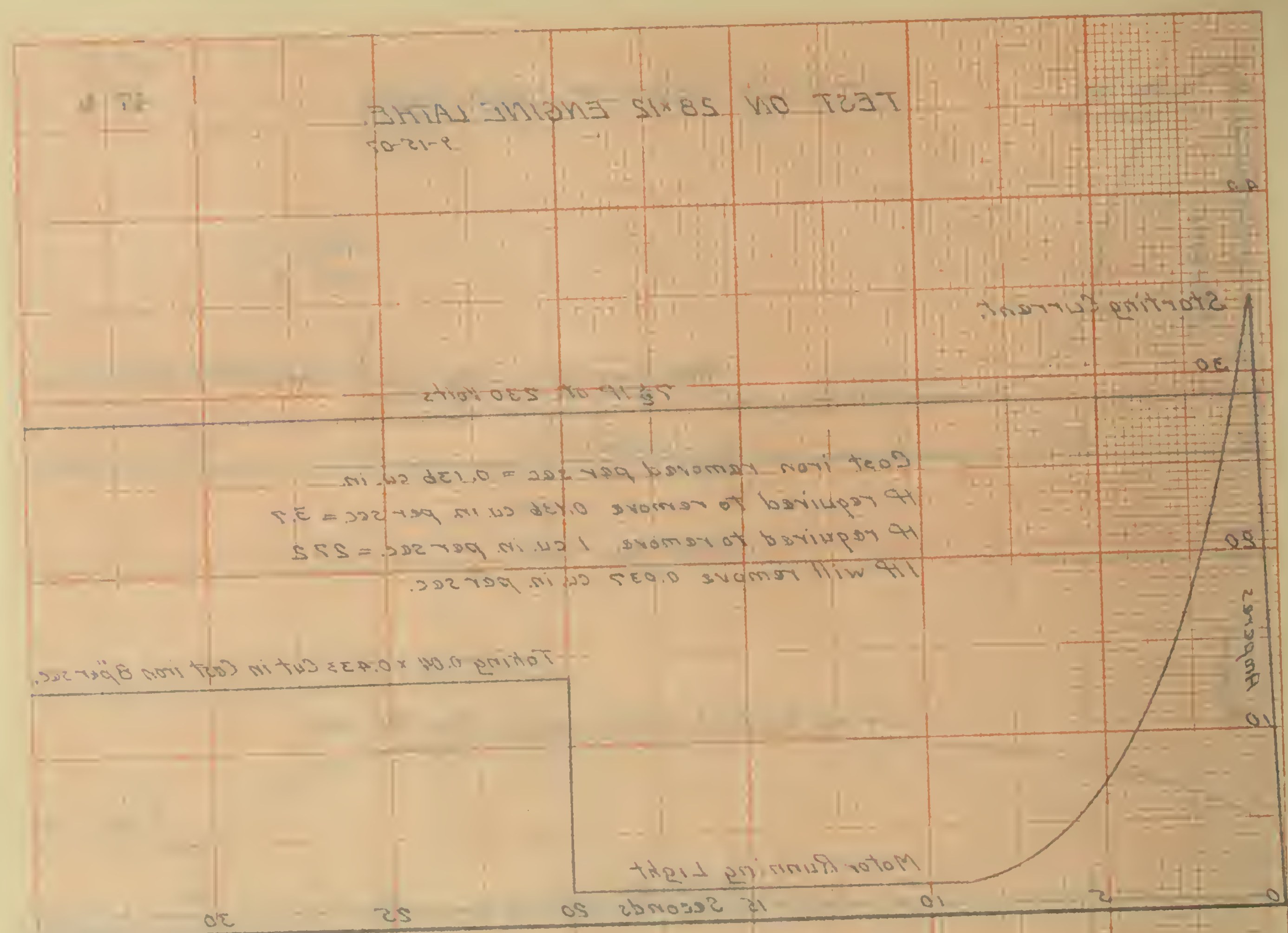
TEST ON NEWTON COLD-SAW
9-15-07.
Starting Current.
Amperes.
Volts 235
R.P.M. 965
Saw Rotating
Table forward, saw running light.
Saw carriage returning.
0 5 10 15 Seconds 20 25 30
5 HP at 235 Volts
Amperes.
Sawing 8" Steel driver shaft. Time 30 min.
5 10 15 Minutes 20 25 30
B.S.P.

TEST ON 18" SLOTTER
9-14-07.
Starting Current.
Amperes.
7 HP at 235 Volts
Cut: 6" long × 1/16" × 7/8" wide – Cast Steel.
Stroke of tool set to 9"
Speed with load, 1st. point on – – – 814 R.P.M.
Speed without load, 1st. point on – – 818 R.P.M.
Cutting Stroke 6" long
Back Stroke
0 4 8 12 Seconds 16 20 24

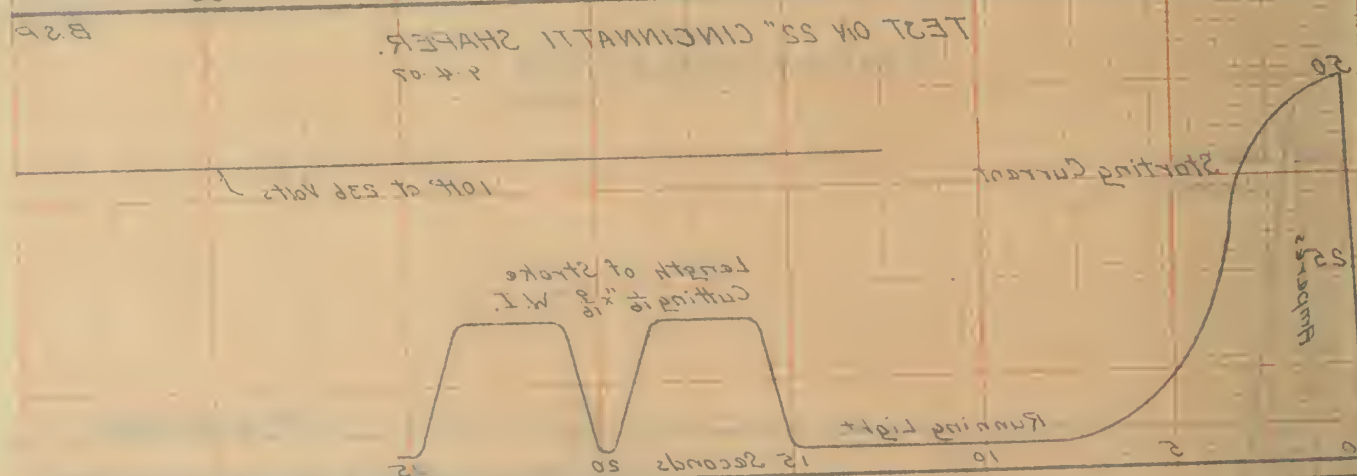


TEST ON NEWTON COLD-SAW
9-15-07
Volts 235
R.P.M. 985
Starting Current
Amperes
Saw carriage returning
Table forward, saw running light
Saw Rotating
30 25 Seconds 20 15 10 5 0
7.5 H.P. at 235 Volts
Amperes
Sawing 8" steel driver shaft Time 30 min.
30 25 20 15 Minutes 10 5
B.S.P.
TEST ON 18" SLOTTER
9-16-07
Starting Current.
7 H.P. at 235 Volts
Cut: 6" long × 1/2 × 7/8" wide – Cast Steel.
Stroke of tool set to 9"
Speed with load, 1st point on --- 814 R.P.M.
Speed without load, 1st point on 818 R.P.M.
Back Stroke
Cutting Stroke 6" long
Amperes
24 20 16 Seconds 12 8 4 0

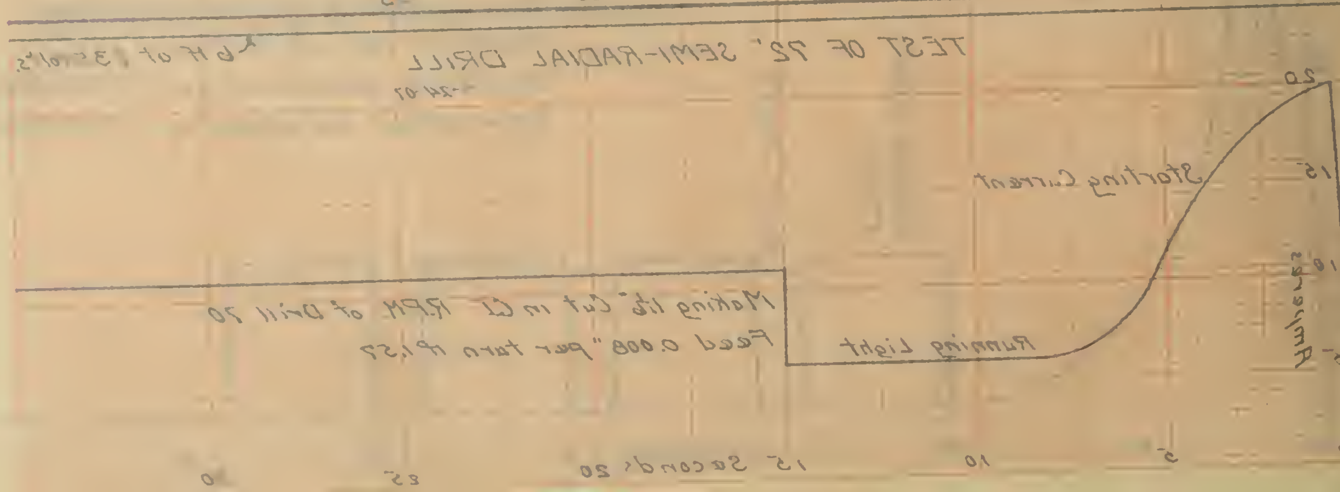

TEST ON 28×12 ENGINE LATHE.
9-15-07
40
Starting Current.
30
7½ HP at 230 Volts
Cast iron removed per sec = 0.136 cu. in.
HP required to remove 0.136 cu. in. per sec. = 3.7
HP required to remove 1 cu. in. per sec. = 27.2
1 HP will remove 0.037 cu. in. per sec.
20
Amperes
Taking 0.04 × 0.433 Cut in Cast iron 8" per sec.
10
Motor Running Light
0
5
10
15 Seconds
20
25
30
B.S.P
TEST ON 22" CINCINNATTI SHAPER.
9-4-07
50
Starting Current
10 HP at 236 Volts.
Length of Stroke
Cutting 1/16" × 9/16" W.I.
25
Amperes
Running Light.
0
5
10
15 Seconds
20
25
6 HP at 235 Volts.
TEST OF 72" SEMI-RADIAL DRILL
9-24-07
20
15
Starting Current
10
Amperes
Making 1 1/16" Cut in C.I. R.P.M. of Drill 70
Feed 0.008" per turn HP 1.57
Running Light
5
0
5
10
15 Seconds
20
25
30



TEST ON 28×12 ENGINE LATHE.
9-15-07
Starting Current.
7½ HP at 230 Volts
Cast iron removed per sec = 0.136 cu. in.
HP required to remove 0.136 cu in per sec = 3.7
HP required to remove 1 cu. in. per sec. = 27.2
1 HP will remove 0.037 cu in per sec.
Taking 0.04 × 0.433 Cut in Cast iron 8″ per sec.
Motor Running Light
Amperes
Seconds



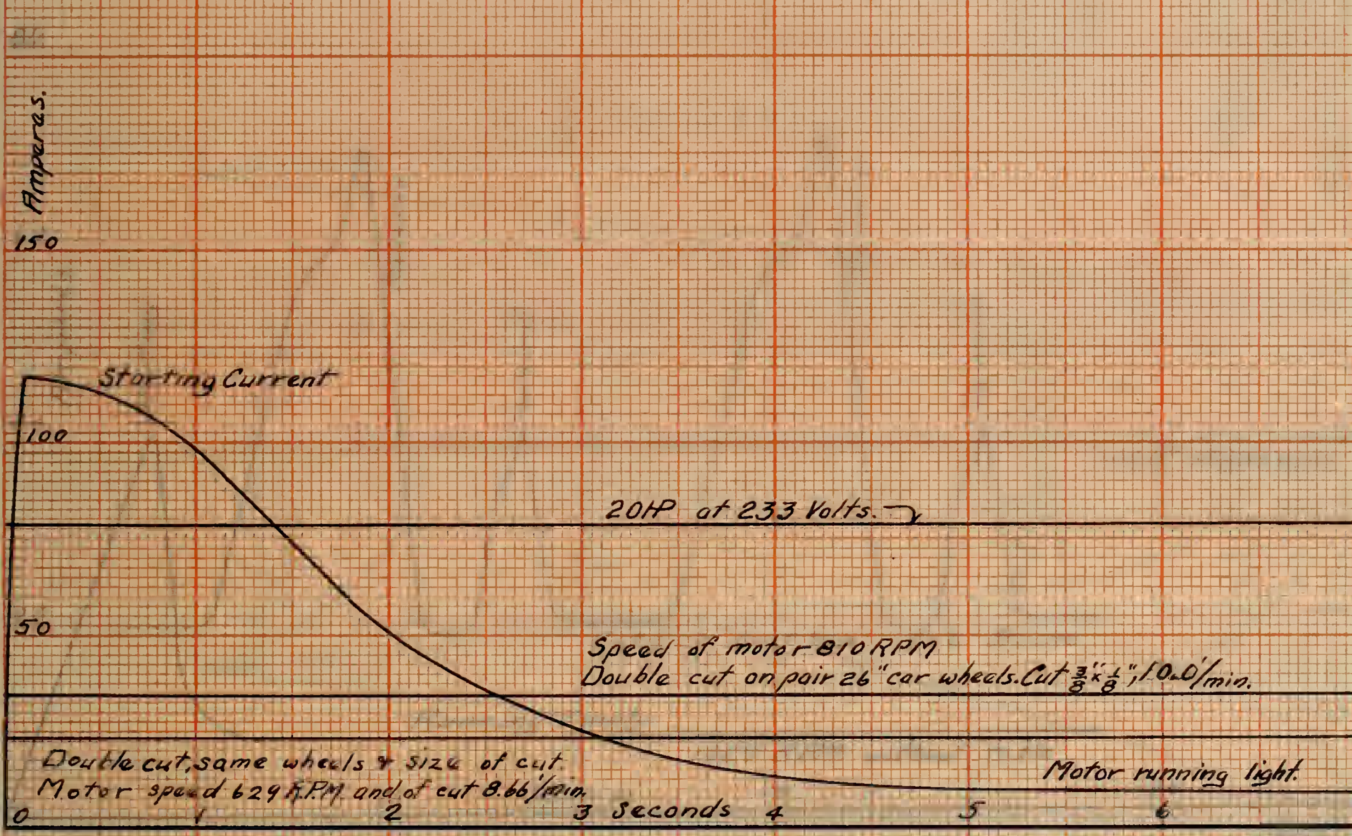
TEST ON 22" CINCINNATTI SHAPER.
9-4-07
B.S.P
10 HP at 236 Volts
Starting Current
Length of Stroke
Cutting 1/16 × 3/8 W.I.
Running Light
Amperes
Seconds



TEST OF 72" SEMI-RADIAL DRILL
Starting Current
Making 1/2" Cut in C.I. RPM of Drill 70
Feed 0.008" per turn HP 1.57
Running Light
Amperes
Seconds

TEST OF 79" WHEEL LATHE.

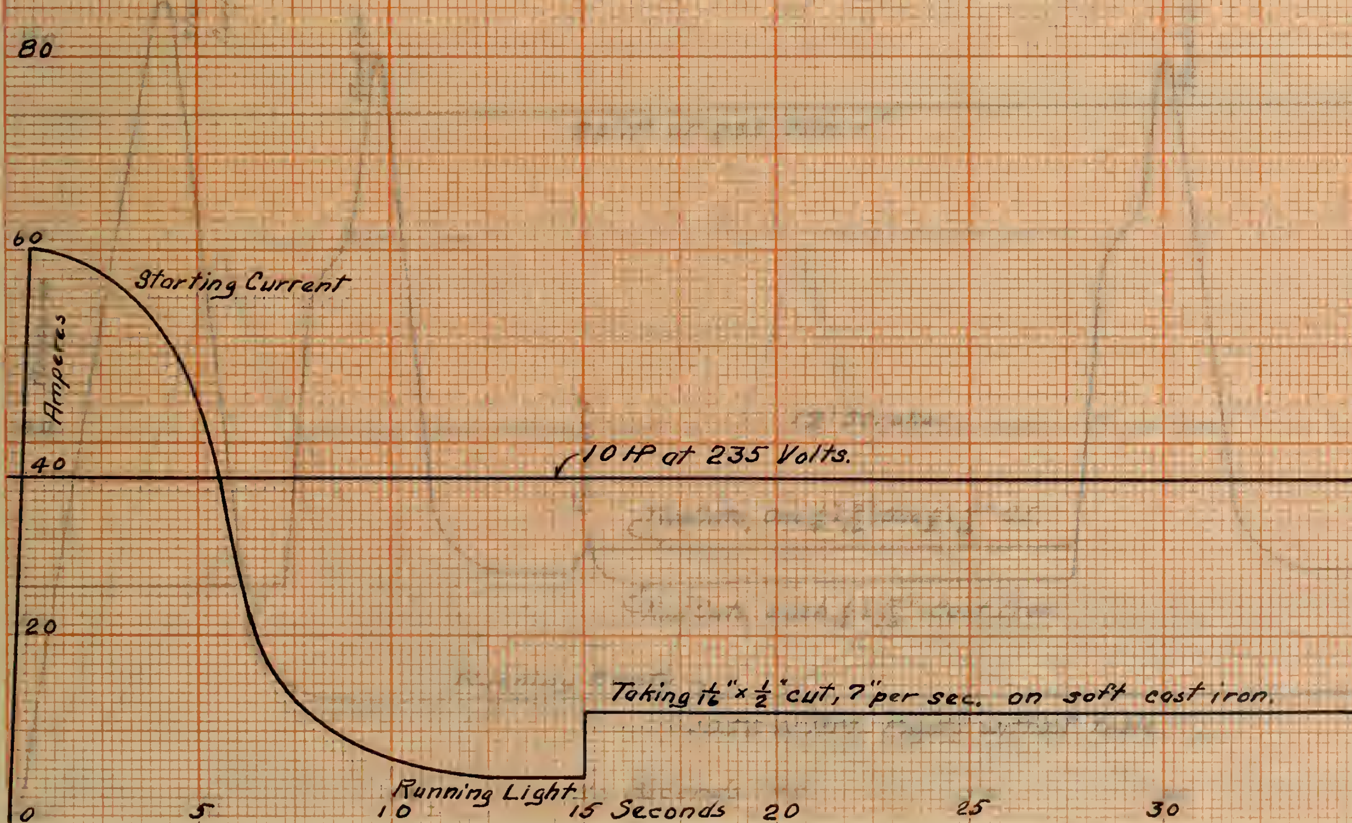
8-29-07.

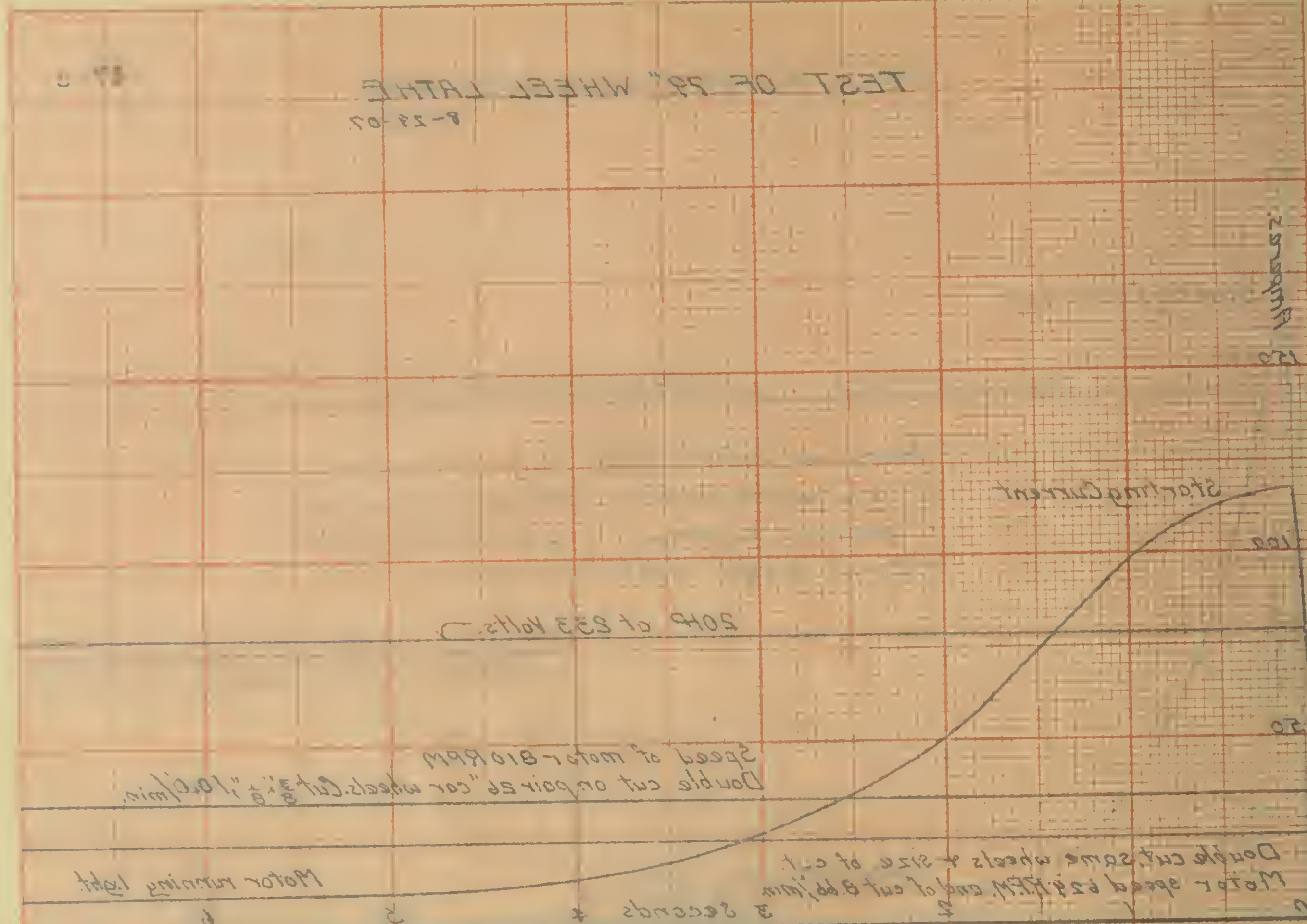


B.S.P.

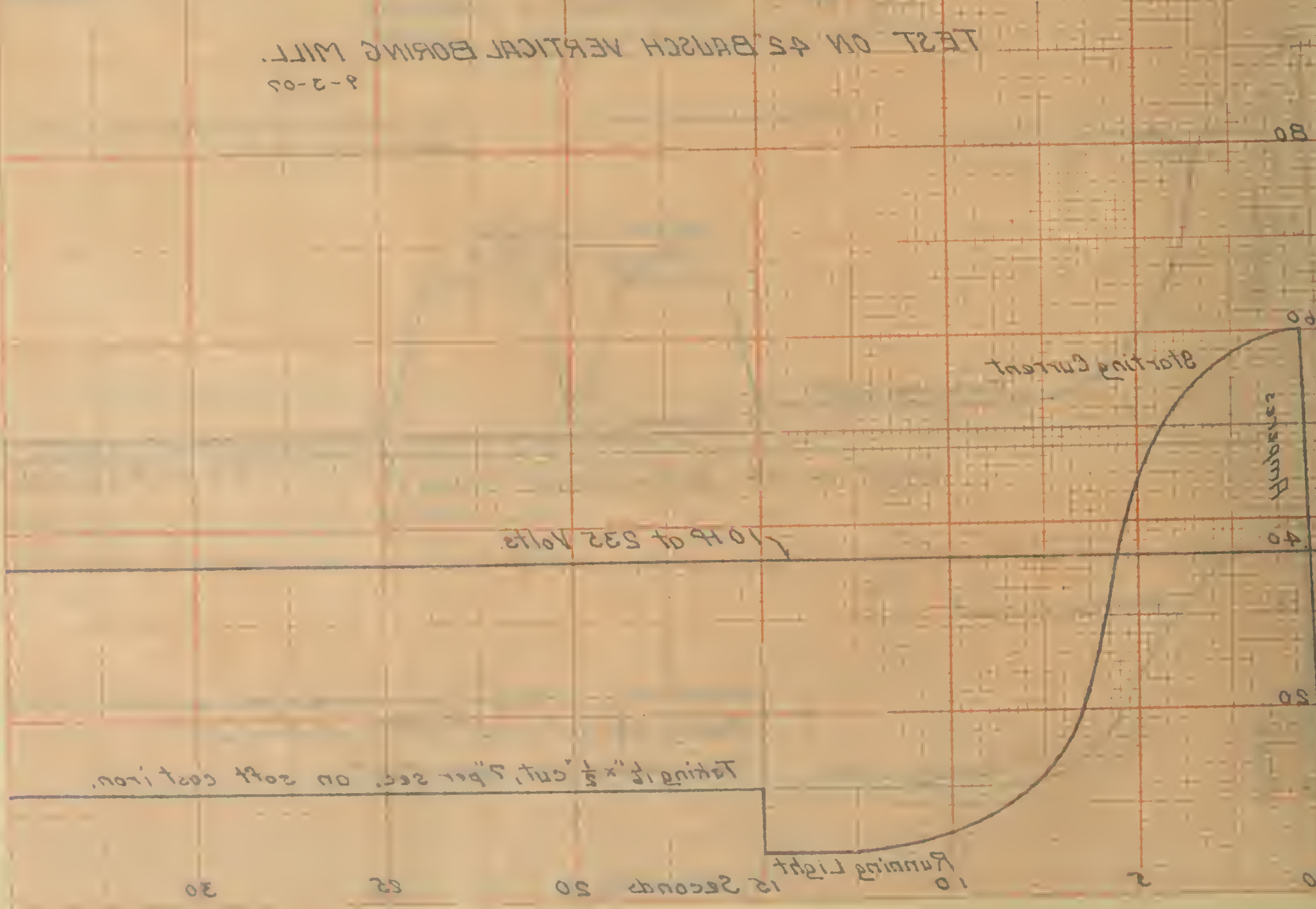
TEST ON 42" BAUSCH VERTICAL BORING MILL.

9-3-07



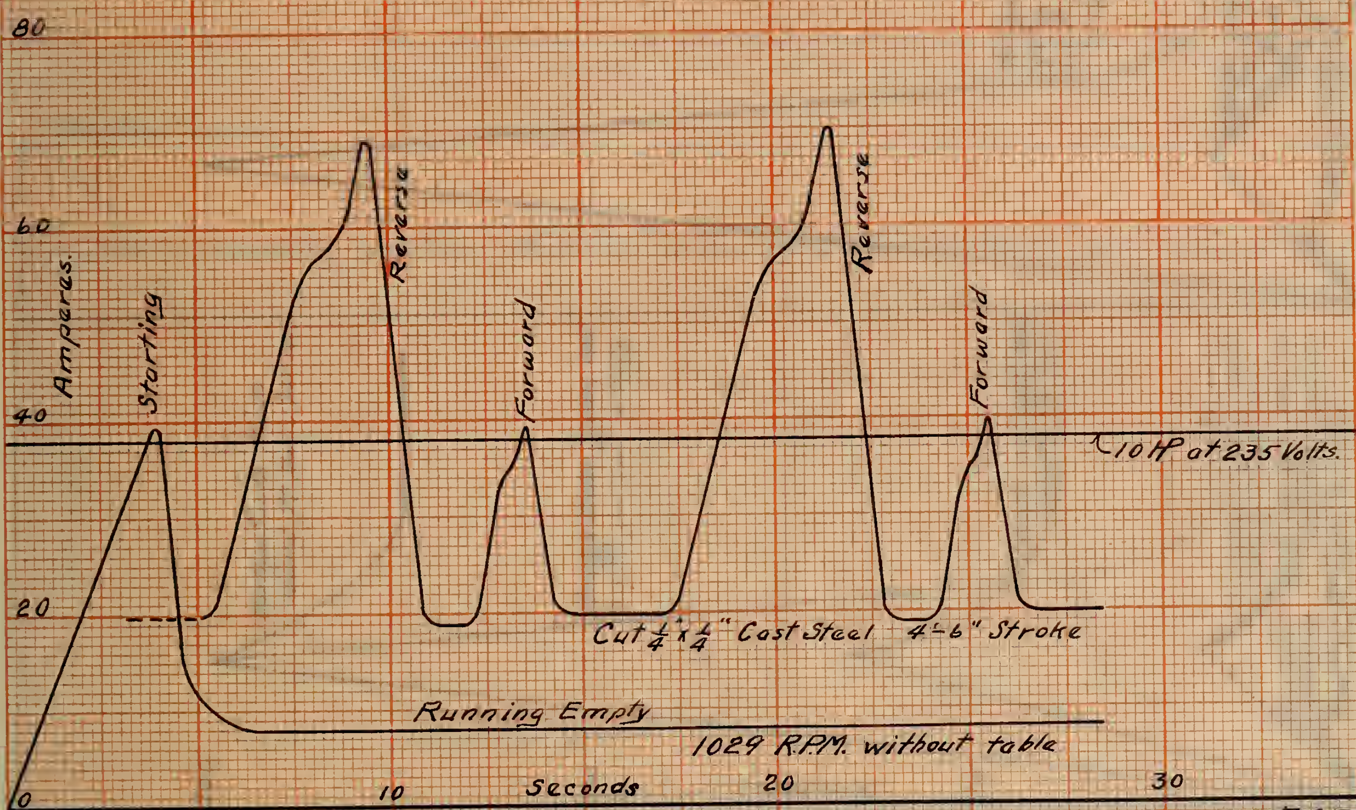

TEST OF 79" WHEEL LATHE.
8-29-07
Amperes
150
100
50
0
Starting Current
20HP at 233 Volts.
Speed of motor-810 RPM
Double cut on pair 26" car wheels. Cut 3/8" x 1/4" 10.0'/min.
Double cut, same wheels & size of cut.
Motor speed 629 R.P.M. end of cut 8.66'/min.
Motor running light
1
2
3 Seconds 4
5
6

E.S.P.


TEST ON 42" BAUSCH VERTICAL BORING MILL.
9-3-07
Amperes
80
60
40
20
0
Starting Current
10HP at 235 Volts.
Taking 1 1/2" x 1/2" cut, 7" per sec. on soft cast iron.
Running Light
5
10
15 Seconds 20
25
30

TEST ON 42×42×16 NILES PLANER.

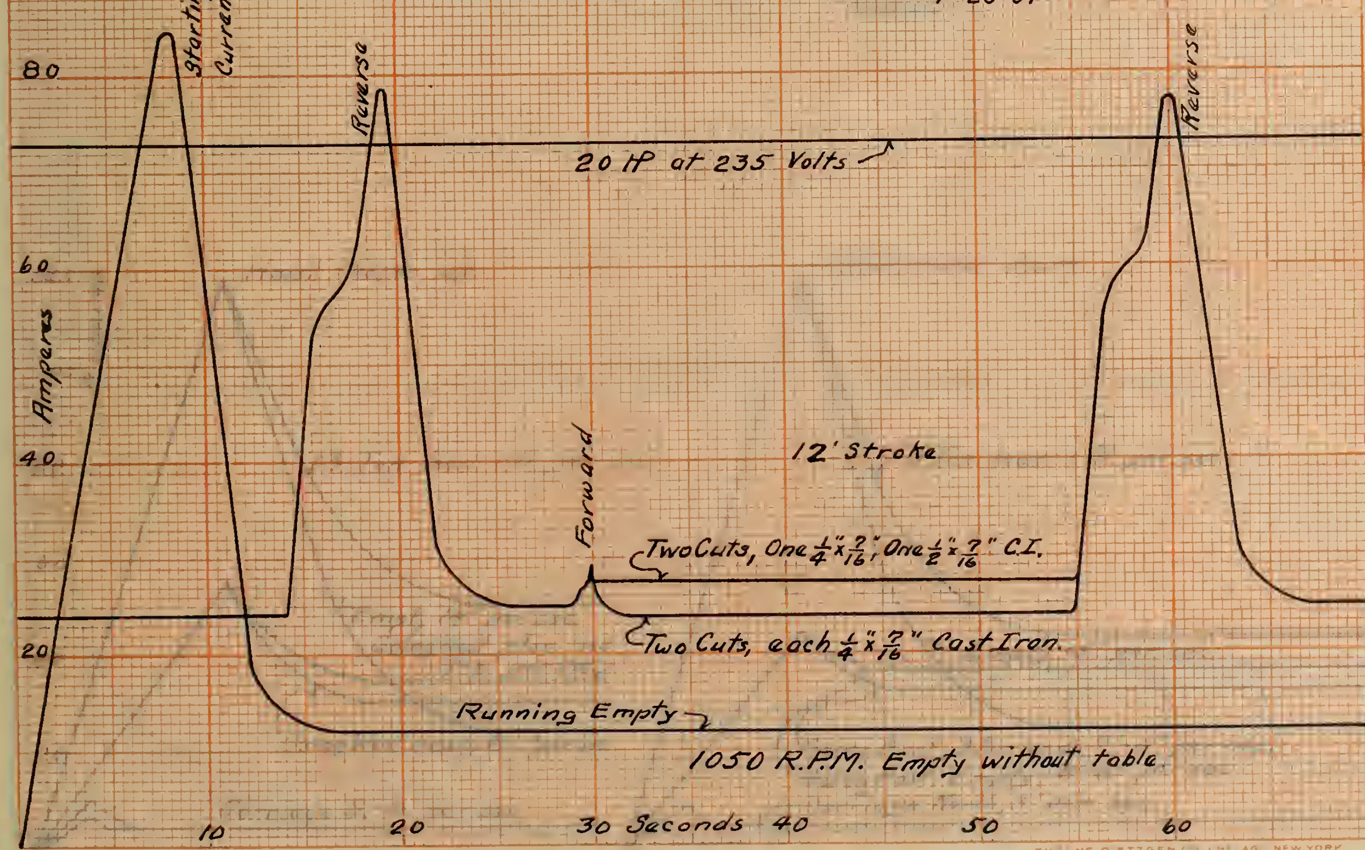
9-30-07.

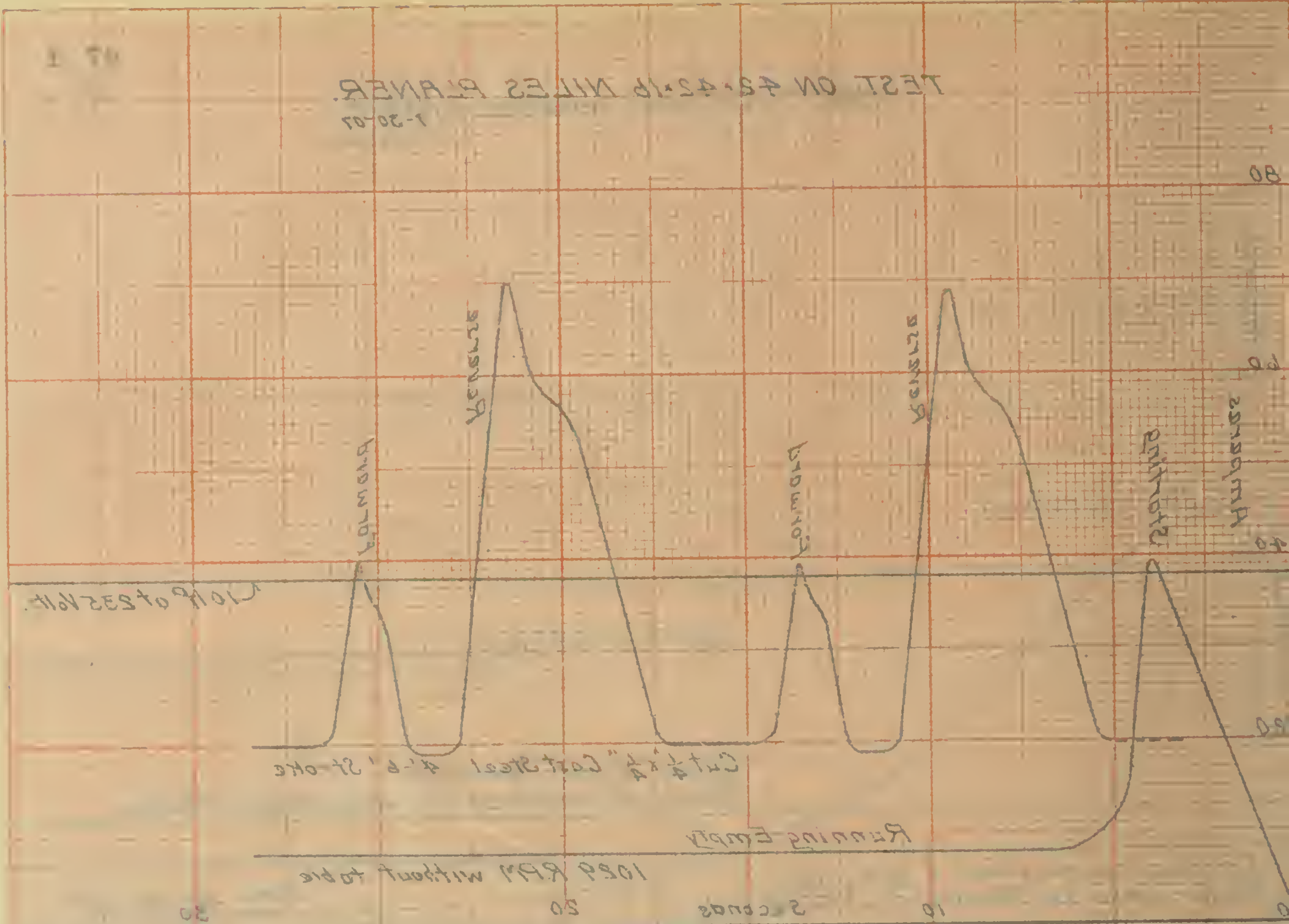


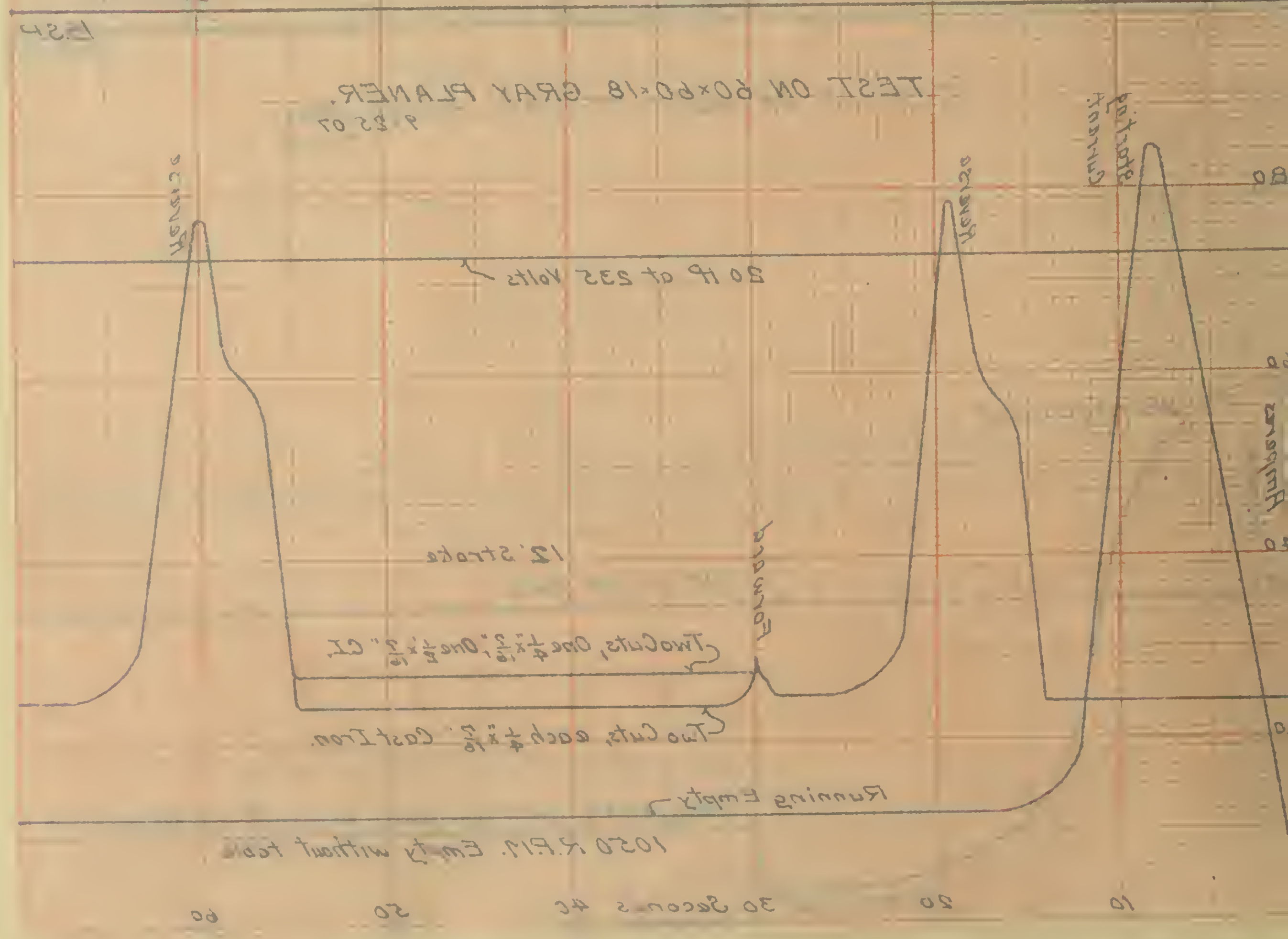
B.S.P.

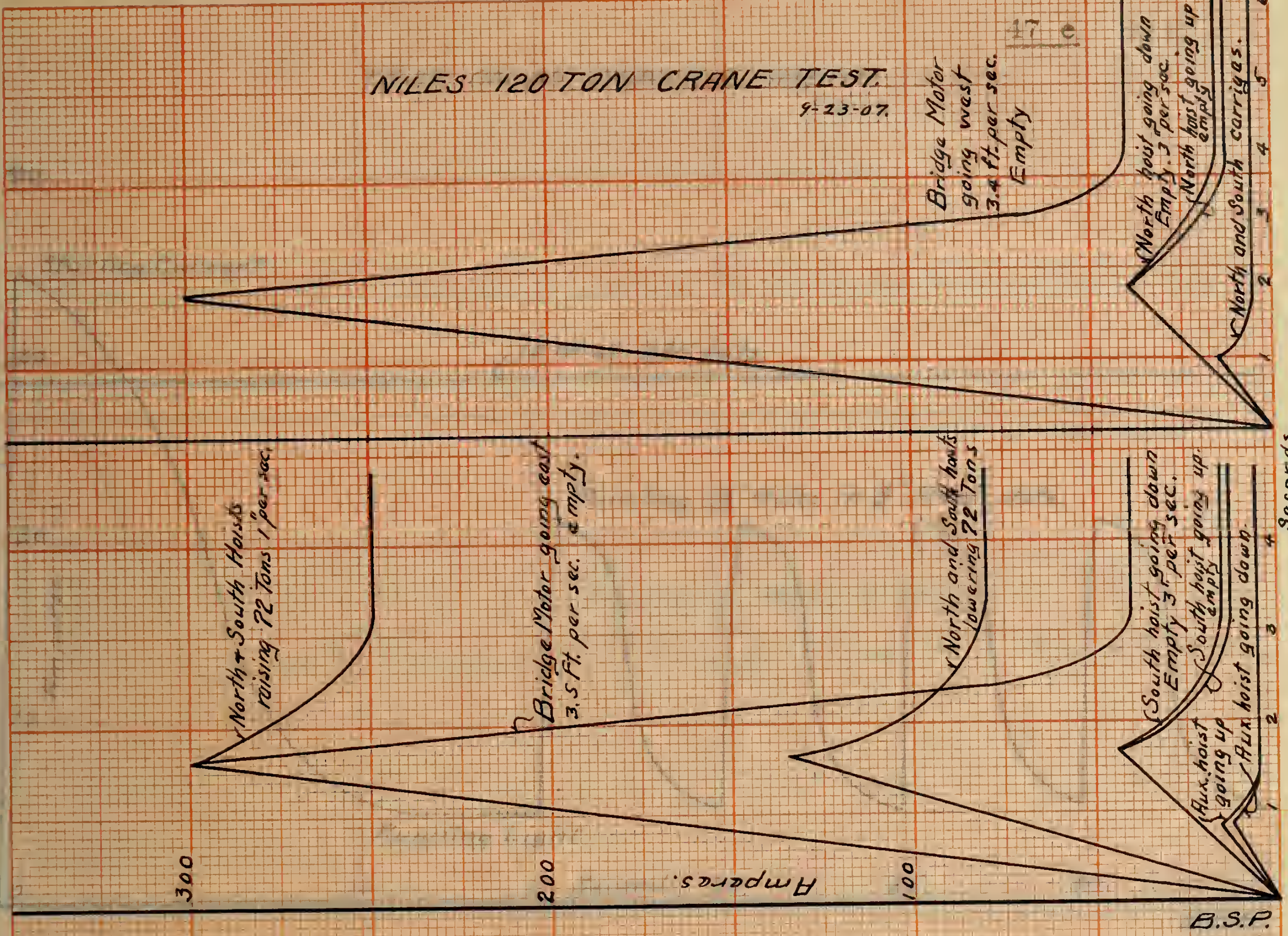
TEST ON 60×60×18 GRAY PLANER.

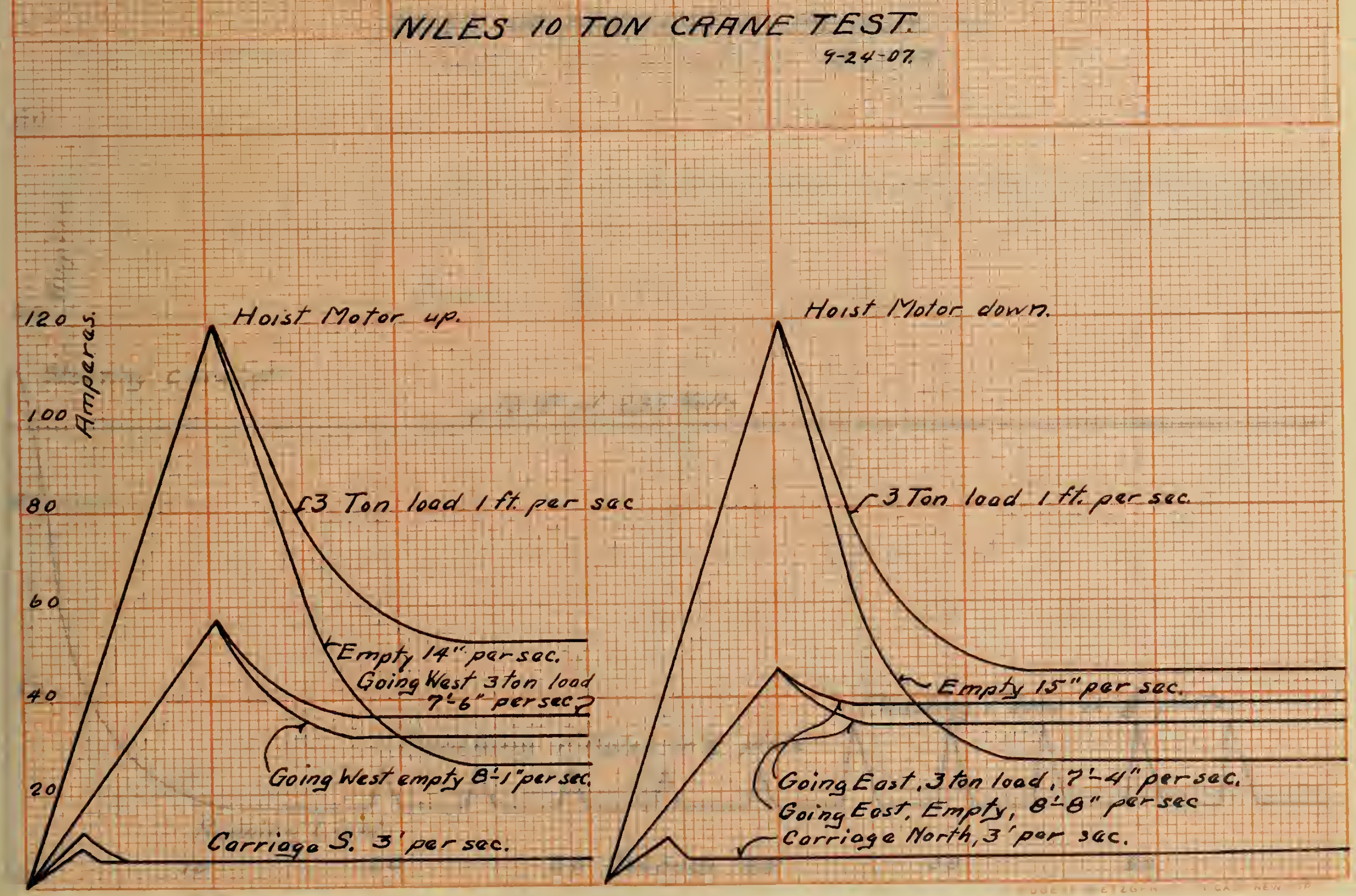
9-25-07

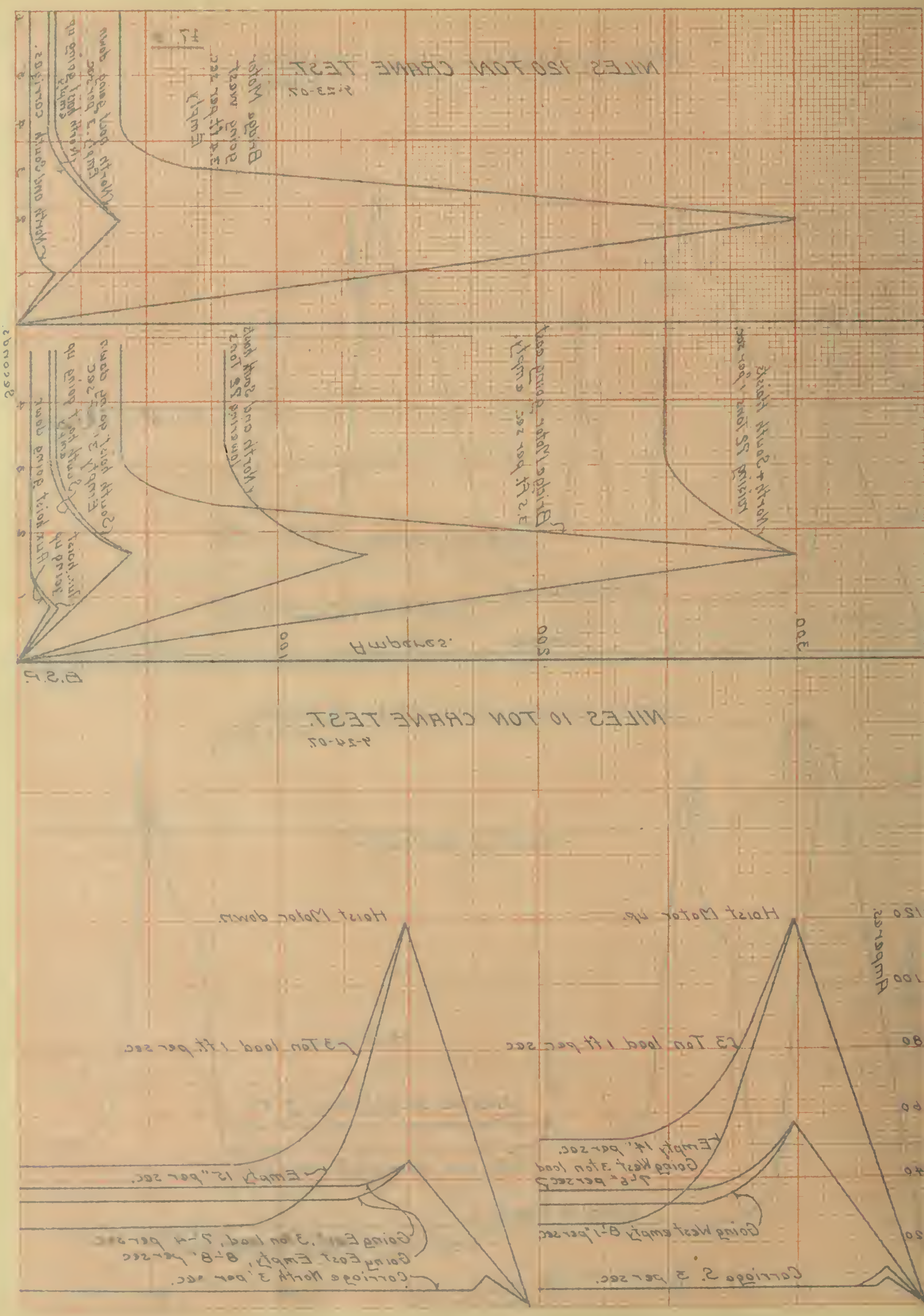



TEST ON 42×42×16 NILES PLANER.
7-30-07
10 HP at 235 Volt.
Forward
Reverse
Forward
Reverse
Starting
Amperes
80
60
40
20
0
Cut 1/4 x 1/4" Cast Steel 4'-6" Stroke
Running Empty
1029 R.P.M. without table
30
20
Seconds
10
0


15 HP
TEST ON 60×60×18 GRAY PLANER.
9-25-07
Reverse
Reverse
Starting Current
80
20 HP at 235 Volts
60
Amperes
20
0
12' Stroke
Forward
Two Cuts, One 1/4 x 3/16, One 1/2 x 3/16" C.I.
Two Cuts, each 1/4 x 3/16 Cast Iron.
Running Empty
1050 R.P.M. Empty without tools
60
50
30 Seconds 40
20
10

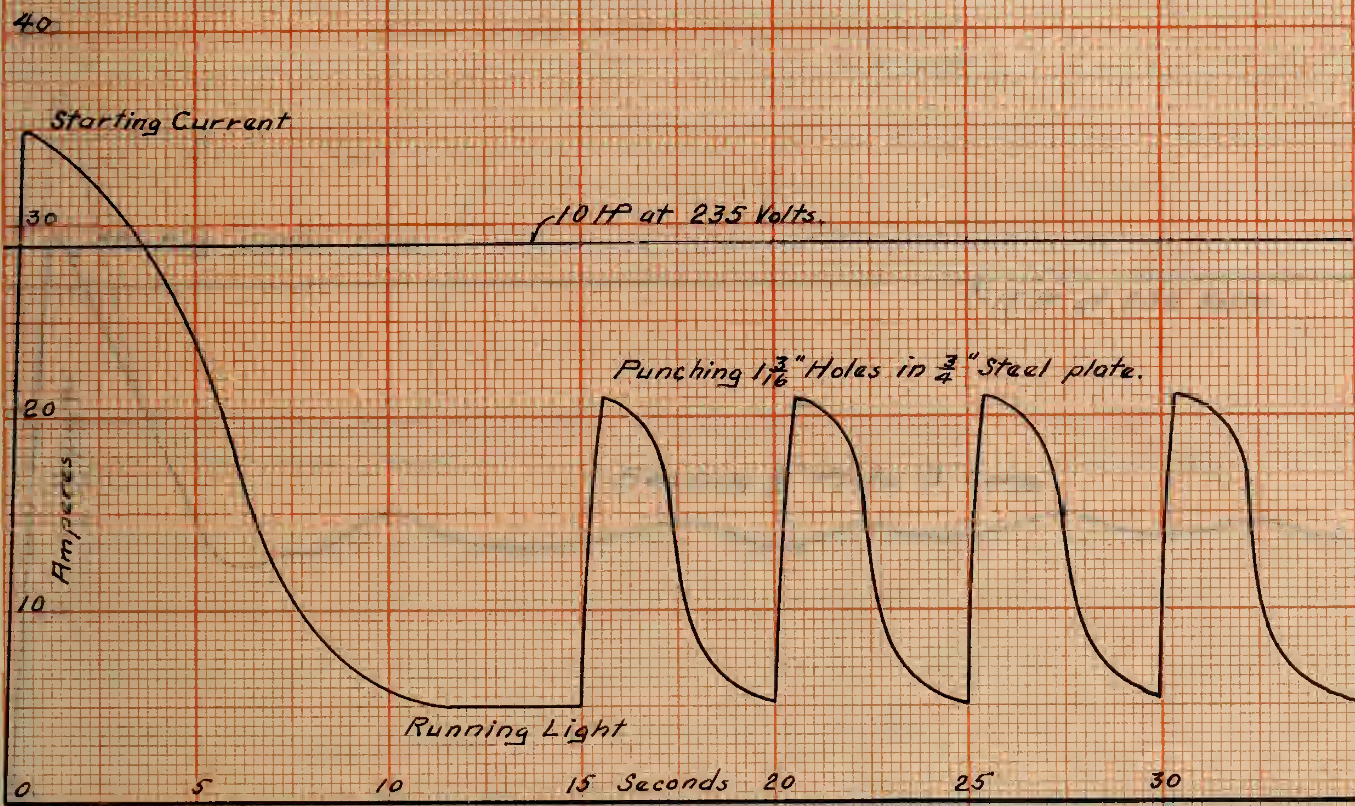

17 e
NILES 120 TON CRANE TEST.
9-23-07.
Bridge Motor going west 3.4 ft. per sec. Empty
North hoist going down Empty. 3' per sec.
North hoist going up empty
North and South carrigas.
North + South Hoists raising 72 Tons 1" per sec.
Bridge Motor going east 3.5 ft. per sec. empty.
North and South hoists lowering 72 Tons
South hoist going down Empty 3' per sec.
South hoist going up. empty
Aux. hoist going up
Aux. hoist going down.
300
200
100
Amperes.
Seconds.
1
2
3
4
5
6
B.S.P.


NILES 10 TON CRANE TEST.
9-24-07.
Amperes.
120
100
80
60
40
20
Hoist Motor up.
3 Ton load 1 ft. per sec
Empty 14" per sec.
Going West 3 ton load 7'-6" per sec
Going West empty 8'-1" per sec.
Carriage S. 3' per sec.
Hoist Motor down.
3 Ton load 1 ft. per sec.
Empty 15" per sec.
Going East, 3 ton load, 7'-4" per sec.
Going East, Empty, 8'-8" per sec
Carriage North, 3' per sec.


NILES 120 TON CRANE TEST.
9-23-07
NILES 10 TON CRANE TEST.
9-24-07
Amperes
Seconds
100
200
300
E.S.P.
Hoist Motor down.
Hoist Motor up.
3 Ton load 1 ft per sec.
Empty 15" per sec.
Empty 14' per sec.
Going West 3 ton load 7-6" per sec.
Going West empty 8-1" per sec.
Carriage S. 3' per sec.
Going East 3 ton load, 7-4 per sec.
Going East Empty, 8-8' per sec.
Carriage North 3' per sec.
20
40
60
80
100
120

TEST ON 49" PUNCH & SHEAR.

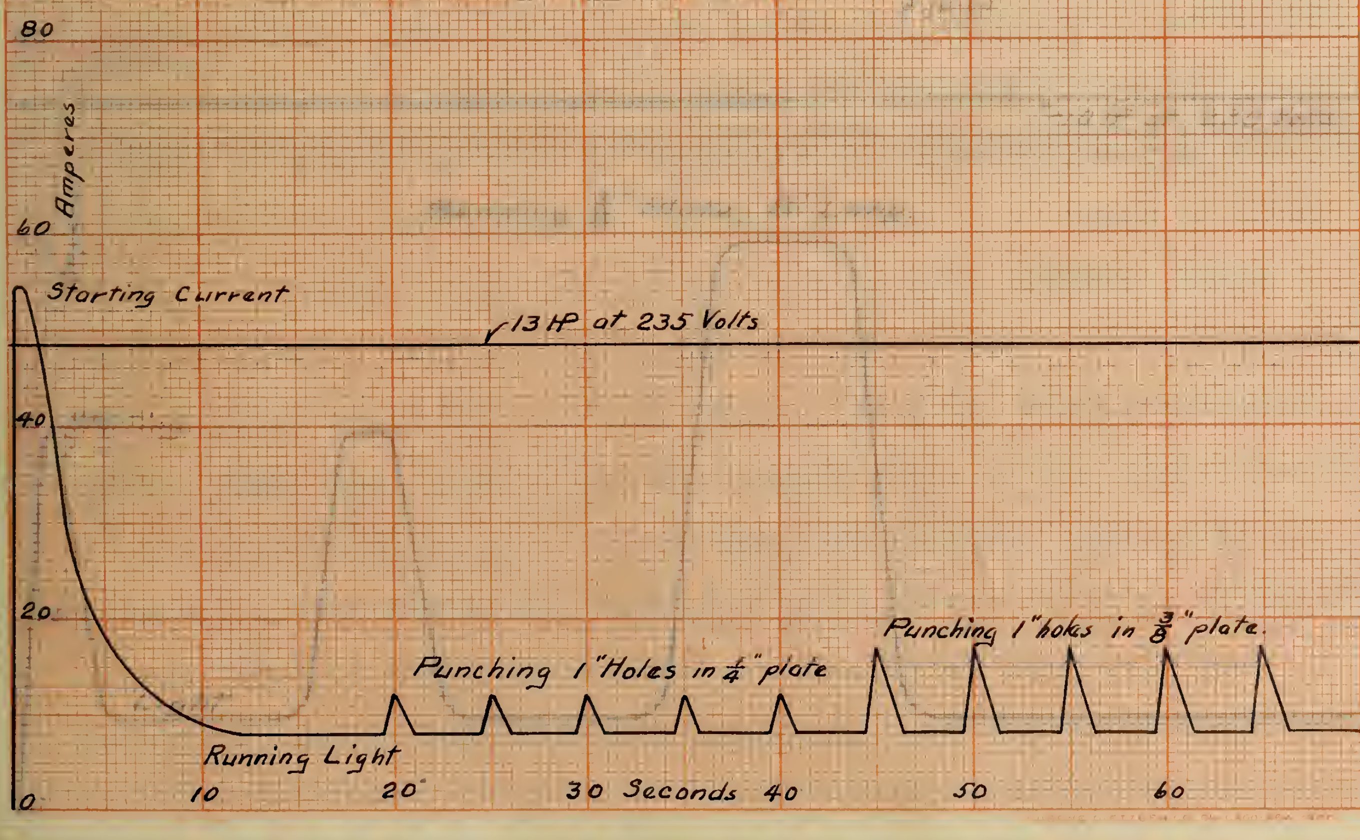
9-2-07.

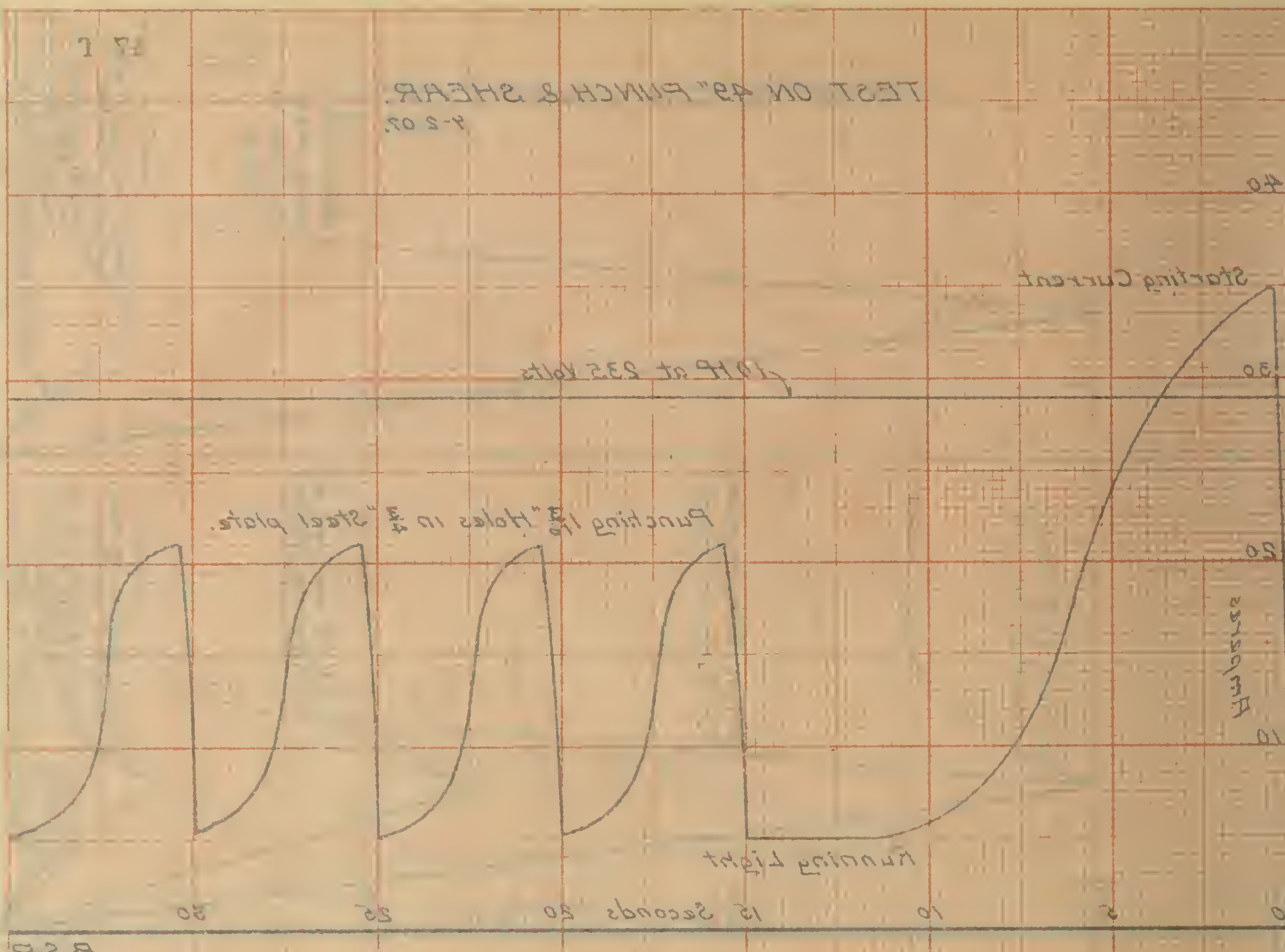


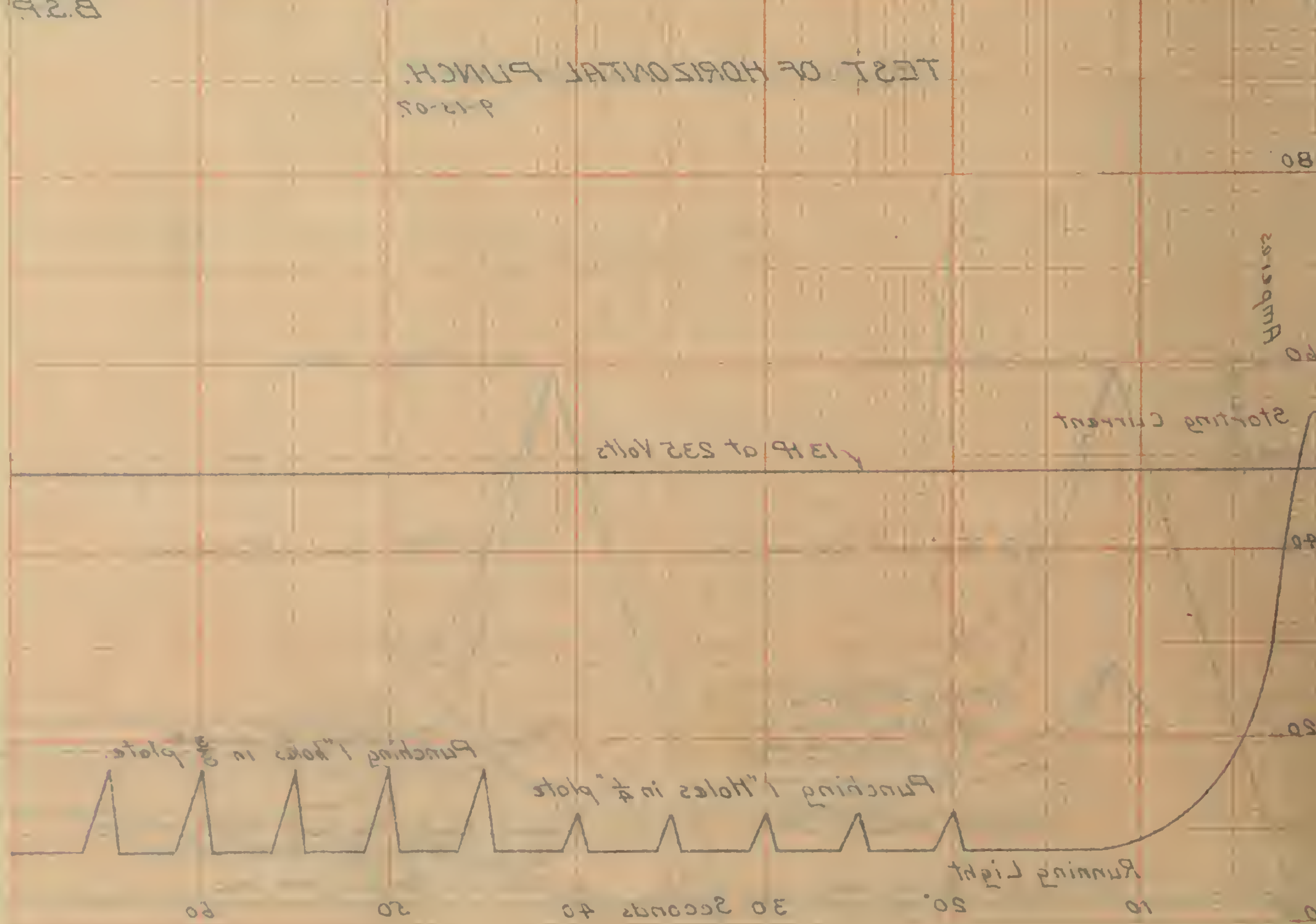
B.S.P.

TEST OF HORIZONTAL PUNCH.

9-13-07.

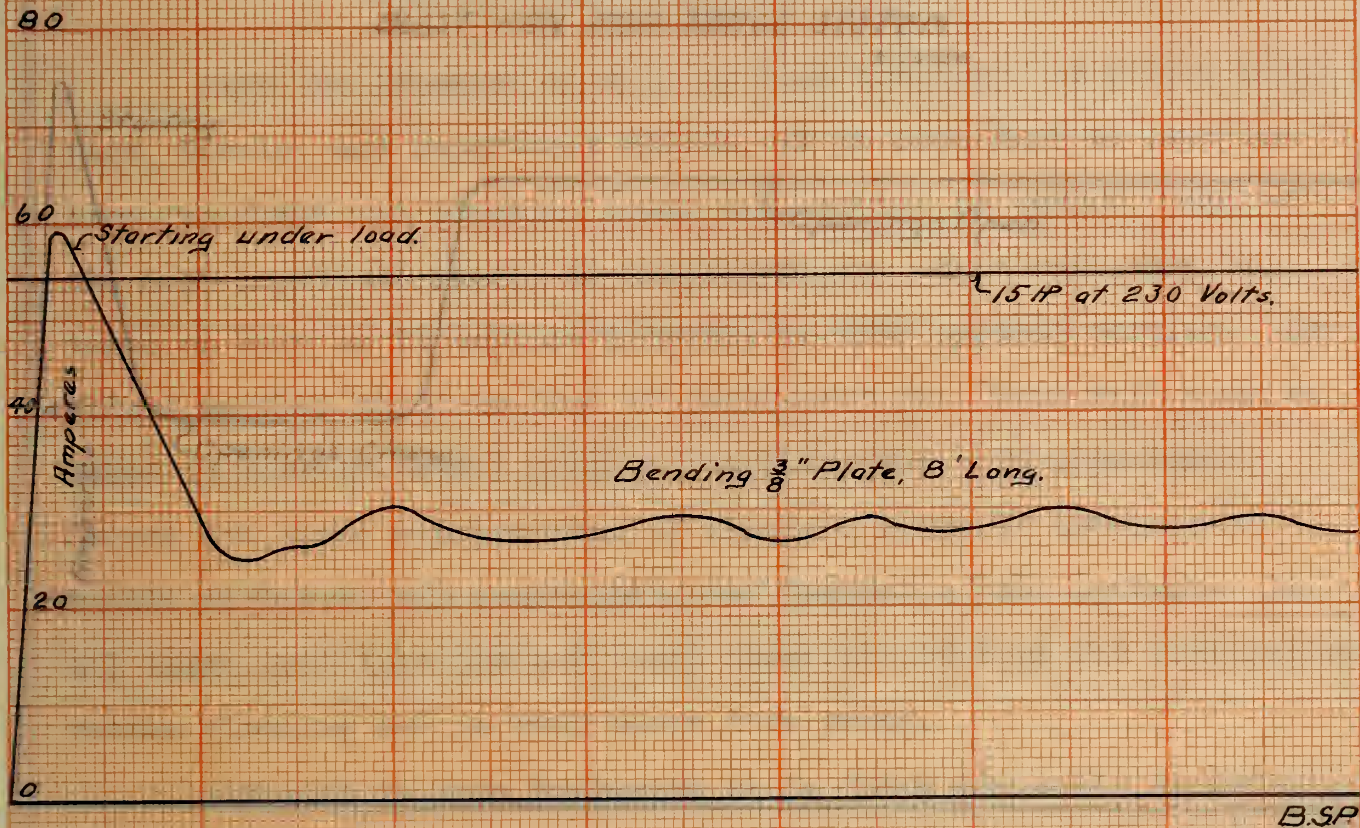



TEST ON 49" PUNCH & SHEAR.
9-2-07.
Starting Current
19 HP at 235 Volts
Punching 1 3/16" Holes in 3/4" Steel plate.
Amperes
Running Light
Seconds
B.S.P.


TEST OF HORIZONTAL PUNCH.
9-13-07.
Amperes
Starting Current
13 HP at 235 Volts
Punching 1" Holes in 5/8" plate.
Punching 1" Holes in 1/4" plate
Running Light
Seconds

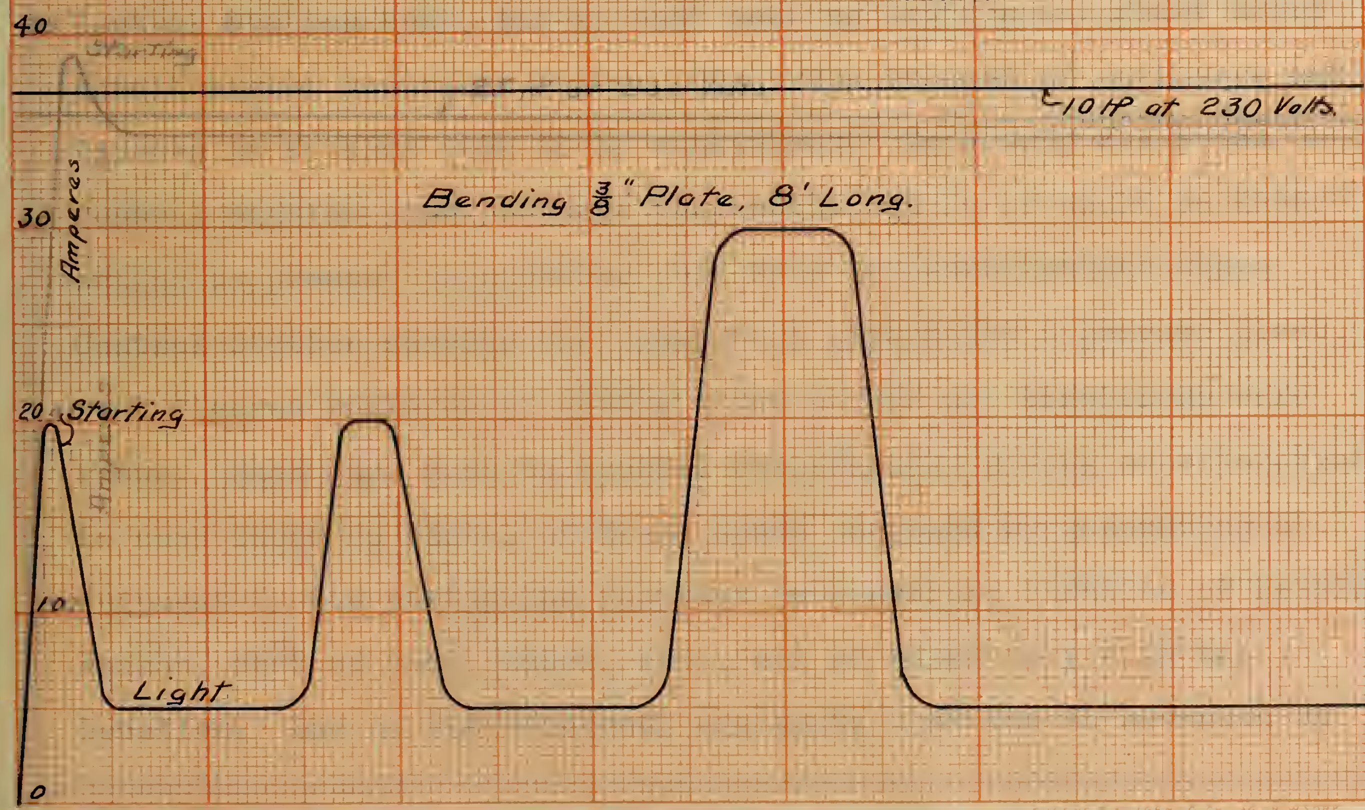
MOTOR FOR TURNING BENDING ROLLS.

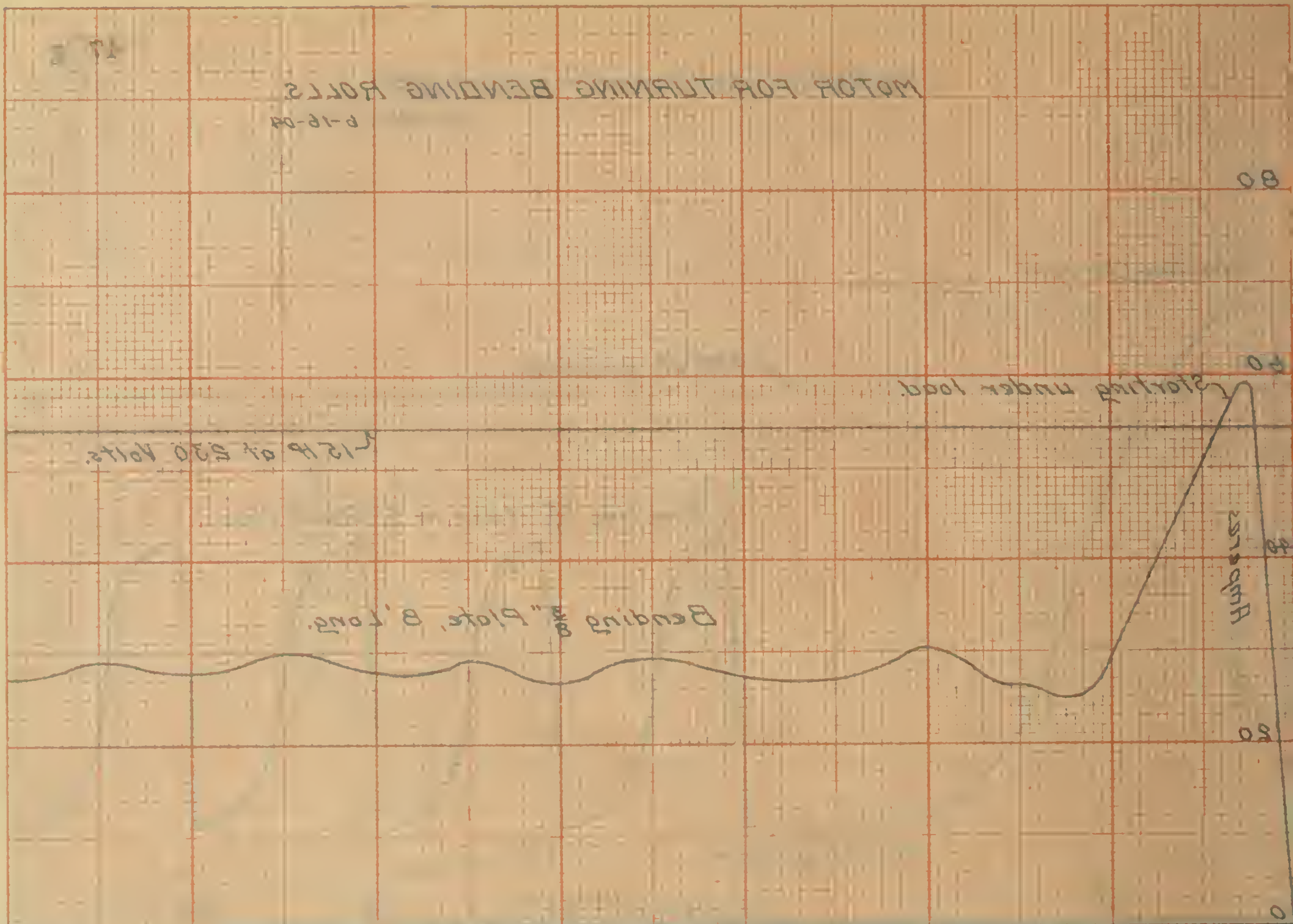
6-16-04

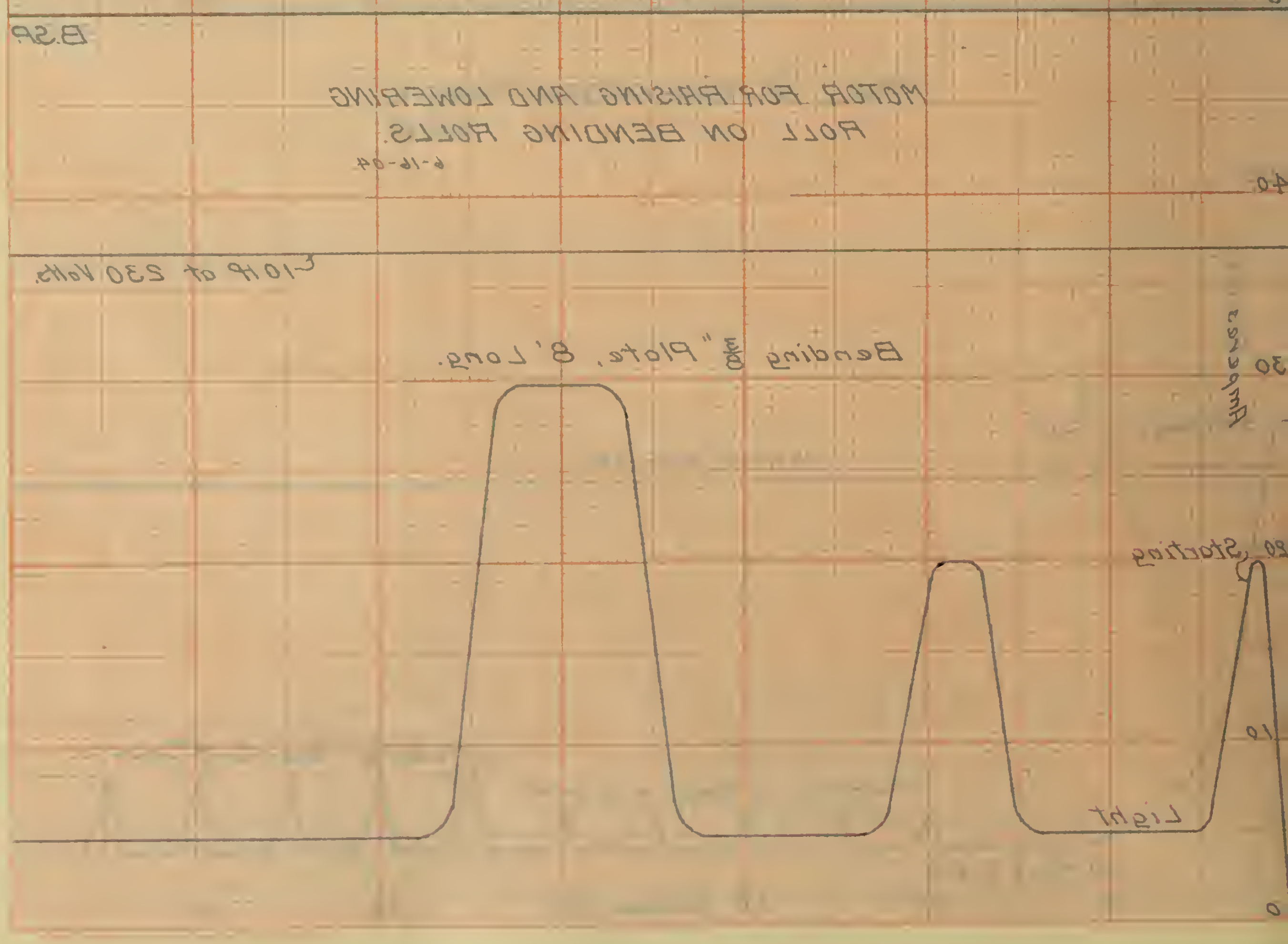


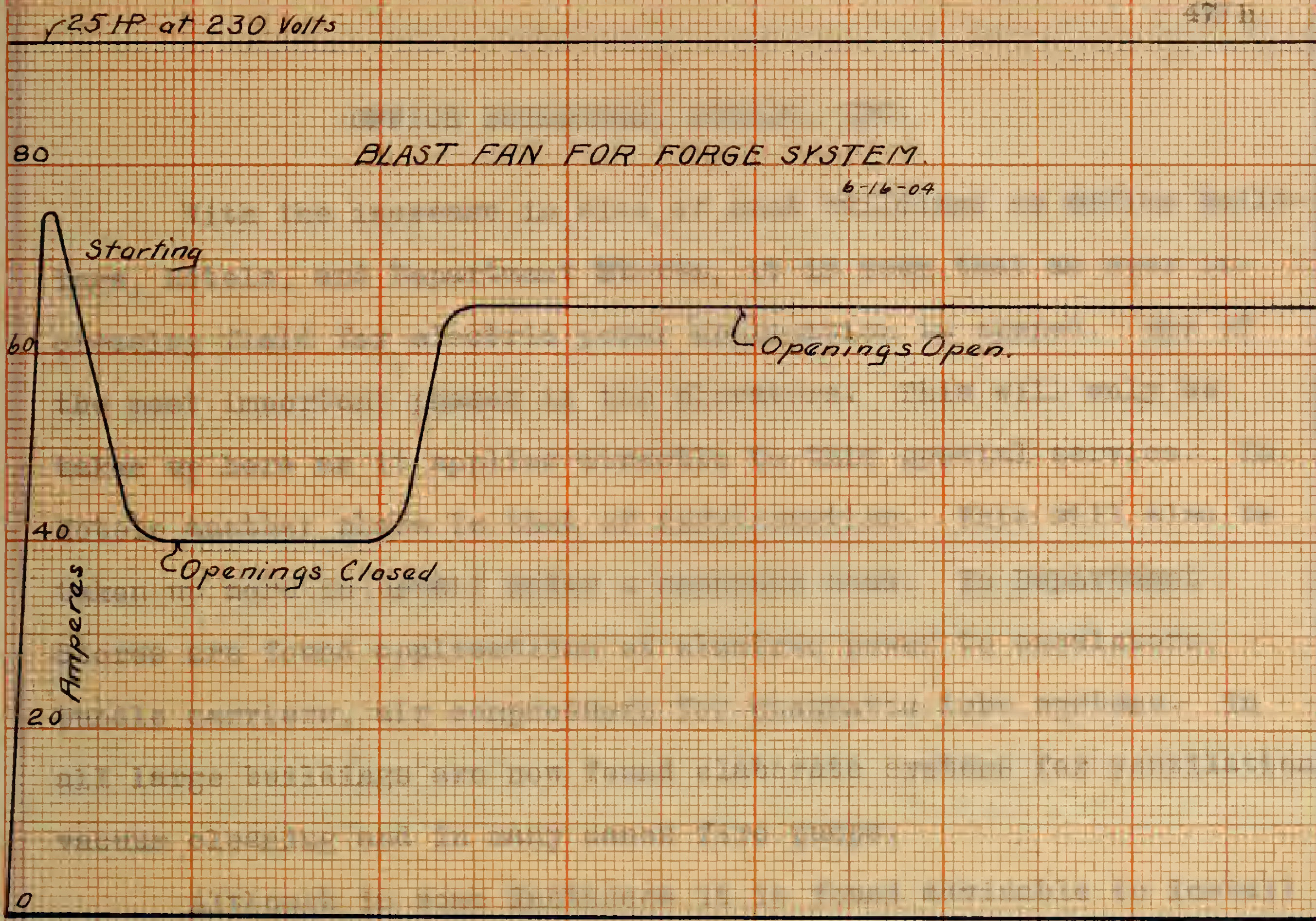
MOTOR FOR RAISING AND LOWERING ROLL ON BENDING ROLLS.

6-16-04

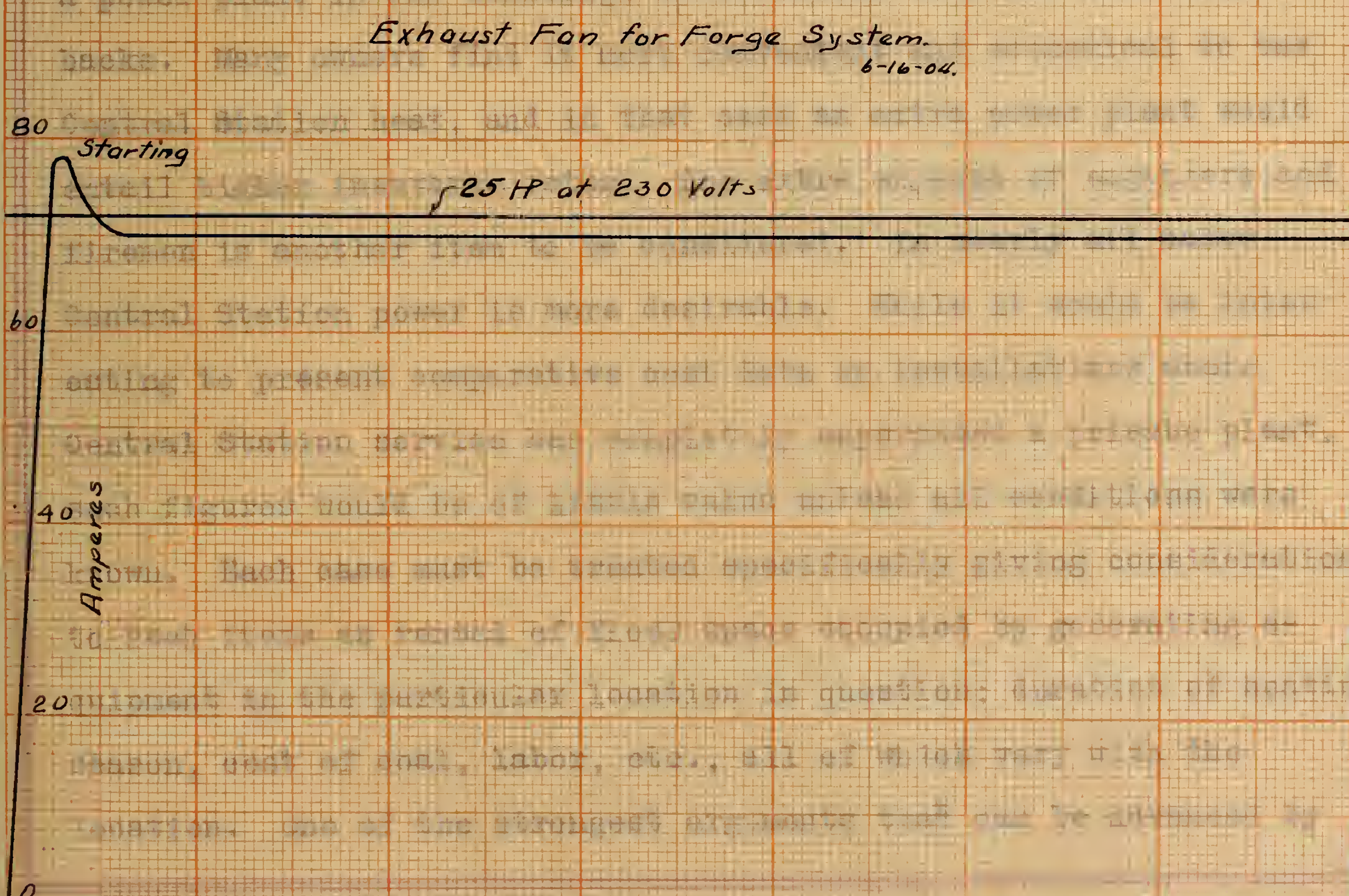


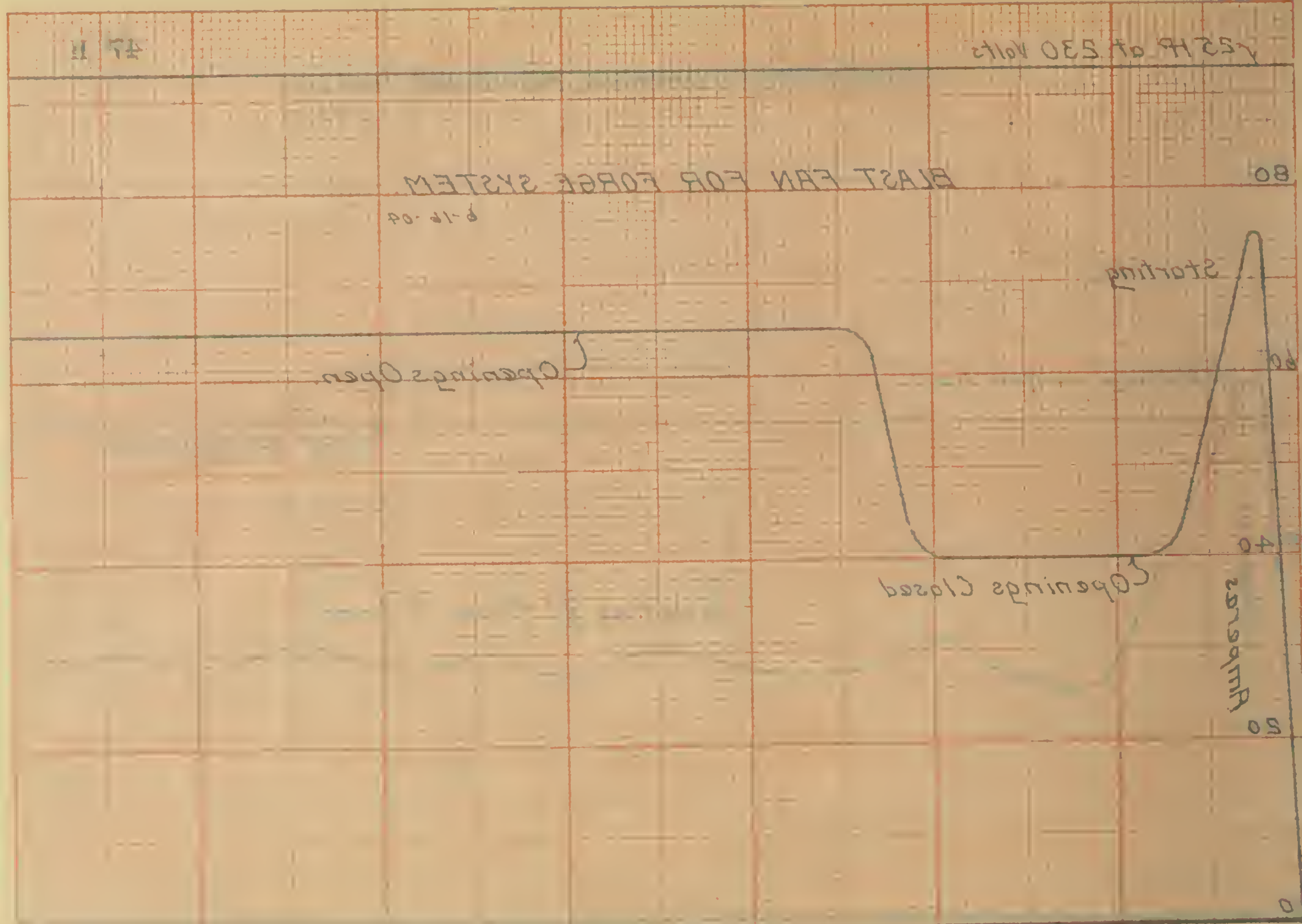

MOTOR FOR TURNING BENDING ROLLS.
6-16-04
Starting under load.
15 HP at 230 Volts.
Bending 3/8" Plate, 8' Long.
Amperes
80
60
40
20
0

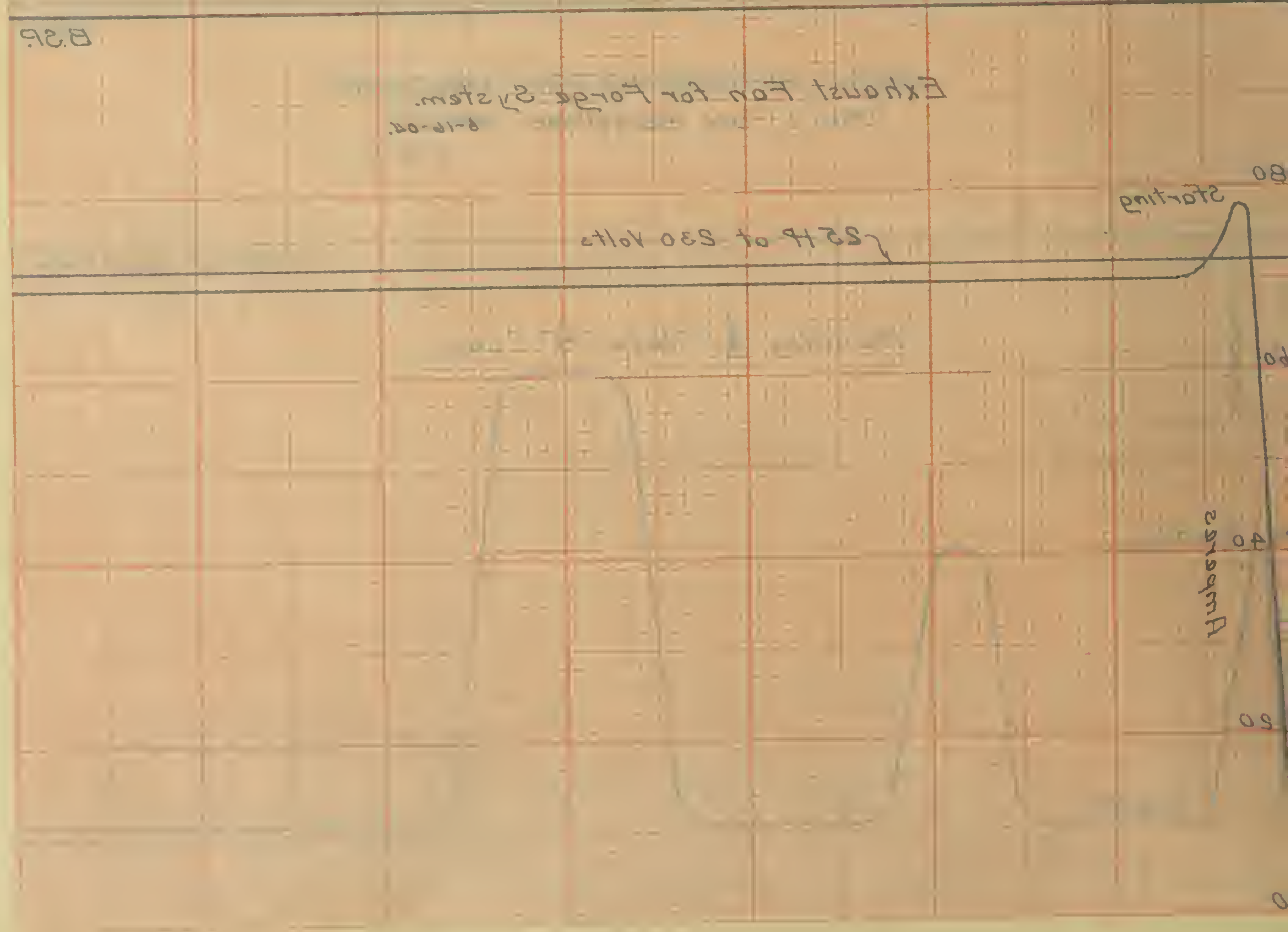

B.S.P.
MOTOR FOR RAISING AND LOWERING
ROLL ON BENDING ROLLS.
6-16-04
10 HP at 230 Volts.
Bending 3/8" Plate, 8' Long.
Amperes
Starting
Light
40
30
20
10
0


25 HP at 230 Volts
BLAST FAN FOR FORGE SYSTEM.
6-16-04
80
Starting
60
Openings Open.
40
Openings Closed
Amperes
20
0

B.S.P.


Exhaust Fan for Forge System.
6-16-04.
80
Starting
25 HP at 230 Volts
60
40
Amperes
20
0


25 HP at 230 Volts
BLAST FAN FOR FORGE SYSTEM
6-16-04
Starting
Openings Open
Openings Closed
Amperes
80
60
40
20
0


B.S.P.
Exhaust Fan for Forge System.
6-16-04.
Starting
25 HP at 230 Volts
Amperes
80
60
40
20
0

OFFICE BUILDINGS, HOTELS, ETC.

With the increase in size of such buildings as Office buildings, Hotels, and Department Stores, it is seen that an ever increasing field for electric power application is opened. One of the most important phases is the elevators. This will only be taken up here as it applies directly to this special service. In Hotels another phase is that of refrigeration. This will also be taken up more in detail under a separate head. In Department Stores are found applications of electric power to escalators, bundle carriers, air compressors for pneumatic tube systems. In all large buildings are now found elaborate systems for ventilation, vacuum cleaning and in many cases fire pumps.

Although in some instances it is found advisable to install a power plant in the building, nevertheless this has some drawbacks. Many owners find it more convenient and economical to use Central Station heat, and in that case an extra power plant would entail higher insurance rates. The extra expense of engineers and firemen is another item to be considered. In nearly all cases Central Station power is more desirable. While it would be interesting to present comparative cost data on installations where Central Station service has completely superseded a private plant, such figures would be of little value unless all conditions were known. Each case must be treated specifically giving consideration to such items as rental of floor space occupied by generating equipment in the particular location in question; duration of heating season, cost of coal, labor, etc., all of which vary with the location. One of the strongest arguments that can be advanced by

Office Buildings, Hotels, etc., cont.

the Central Station salesman in soliciting such business is to name the more prominent establishments purchasing power. In this connection the accompanying list of imposing hotels, all of which are purchasing power, will indicate what progress has been made by Central Station companies in supplying energy for hotel service.

Touraine------------------Boston, Mass.
Genesee-------------------Buffalo, N.Y.
Powers--------------------Rochester, N.Y.
Kernans-------------------Baltimore, Md.
New Willard---------------Washington, D.C.
Raleigh-------------------Washington,D.C.
Colonial------------------Cleveland, O.
Staetler------------------Cleveland, O.
Anderson------------------Pittsburg, Pa.
Henry Watterson-----------Louisville, Ky.
Gault House---------------Louisville, Ky.
Pfister-------------------Milwaukee, Wis.
West----------------------Indianapolis, Ind.
St. Paul------------------St. Paul, Minn.
Pontchartrain-------------Detroit, Mich.
Densmore------------------Kansas City, Mo.
Jefferson-----------------St. Louis, Mo.
Maryland------------------St. Louis, Mo.
Marquette-----------------St. Louis, Mo.
Sherman-------------------Chicago, Ill.
Albany--------------------Denver, Colo.
Grand---------------------Cincinnati, O.
Washington----------------Seattle, Wash.
St. Francis---------------San Francisco, Cal.
Ritz-Carlton--------------Philadelphia, Pa.

Hotels.

Hotel Sherman, Chicago, Ill., 757 rooms.
Total connected load, 838 kilowatts. Average kilowatt-hours per month, 118,825. Load factor 18.4 per cent.

Total connected horsepower, 726. Total number of motors installed, 57. Average kilowatt-hours per month, 64,367. Load-factor, 17 per cent.

MOTOR INSTALLATION

The following is a list of the motors installed with their respective drives. The supply source is 220 volts, direct current.

No.	Horse-power	Speed R. P. M.	Application.
2	5	900	Connected by chain to two circulating ice-water pumps.
1	1	1,200	Belted direct to emery wheel.
2	15	900	Each belted direct to a ventilating fan, 22,500 cubic feet capacity each
2	3.75	1,200	Each driving air washer.
4	36	63	Direct-connected to four 2,500-pound capacity passenger elevators.
1	5	950	Belted to line shaft driving one shirt ironer; two body ironers; one sleeve irioner; one shirt press; and one collar ironer.
1	0.5	550	Belted direct to collar dampener.
1	0.25	1,500	Belted direct to starcher.
1	1	1,200	Direct-connected to extractor.
1	0.25	725	Direct-connected to cuff starcher.
1	1	1,200	Direct-connected to dry room.
1	1	1,200	Direct-connected to flat-work ironer.
1	3	1,200	Belted direct to Trojan mangle.
1	3	1,200	Belteddirect to small mangle.
1	1	1,040	Belted direct to towel driver.
1	1	1,200	Belted to blower for above machine.
2	15	600	Each belted to a line shaft driving six washers, and one extractor.
2	32.5	265	Each direct-connected to Sturtevant exhaust fan, 27,000 cubic feet capacity
1	3	1,650	Direct-connected to New Era dough mixer.
2	40	750	Each belted direct to exhaust fan, capacity 39,000 cubic feet.
1	30	575	Belted direct to 38,000-cubic-foot capacity exhaust fan.
2	25	800	Each driving elevator mechanism.
1	1	2,000	Direct-connected to Golding job press.

Motor Installation (Continued)

The following is a list of the motors installed with their respective drives. The supply source is 220 volts, direct current.

No.	Horse-power	Speed R. P. M.	
1	0.5	1,500	Direct-connected to pony press.
2	25	235	Direct-connected to exhaust fans.
3	1	1,150	Each belted direct to dish washers.
1	20	900	Belted direct to 20,000-cubic foot-capacity blower.
2	25	900	Each belted direct to blower, 27,000 cubic feet capacity
1	3	1,050	Belted direct to ice-cream freezer.
1	0.5	1,600	Belted direct to Read egg beater.
1	0.5	1,100	Belted direct to potato peeler.
1	2	1,840	Belted direct to meat grinder.
1	1.5	1,200	Direct-connected to coffee grinder.
1	0.25	1,400	Belted to carbonator.
1	7.5	900	Belted direct to coal conveyor
1	25	1,500	Belted direct to fan.
1	10	800	Driving freight elevator.
3	9	1,000	Each direct connected to bilge pump.
1	30	575	Belted to fan, capacity 39,000 cubic feet.
1	25	700	Belted direct to fan, 32,500 cubic feet capacity.
1	2	1,100	Belted direct to ice crusher.

St. Paul Hotel, St. Paul, Minn. Has 300 rooms and is 12 stories high.

Total connected load, 400 kilowatts. Average kilowatt-hours per month, 74,000. Load-factor, 26 per cent.

Total connected horsepower 272.5 Total number of motors installed, 33. Average killowatt-hours per month, 41,750. Load-factor, 32.7 per cent.

Motor Installation.

The following is a list of the motors installed with their respective drives. The supply source is 220 volts direct current, and three phase, 60 cycle, 220 volt, alternating current.

No	Horse-power	Speed R.P.M.	Application
1	17.5	800	Direct-connected to one 1,800-pound capacity freight elevator.
1	20	800	Direct-connected to one passenger and freight elevator.
2	35	800	Each direct-connected to one passenger elevator.
1	7.5		Direct-connected to one passenger elevator.
1	35	900	Belted direct to one 15-ton Linde ice machine, supplying 19 boxes.
1	15	900	Belted direct to one 8 by 8-inch air compressor.
1	20	840	Belted direct to one 5 foot 6 inch Sirocco kitchen exhaust fan.
1	20	840	Belted direct to one 5 foot 6 inch main blower fan.
1	7.5	900	Geared to one 90-gallon-per-minute cold water pump.
1	7.5	900	Geared to one 90-gallon-per-minute hot-and-cold-water pump.
1	4.5	900	Geared to one 50-gallon-perCminute hot-water pump.
1	0.33	1,150	Geared to one heat regulator.
1	1	1,150	Belted direct to one air washer.
1	3	1,200	Belted direct to one ice-water circulating pump.
1	7.5	1,165	Connected by silent chain to one vacuum cleaner.
1	0.166	1,200	110-volt motor-generator set for elevator signals.
1	3	1,800	Geared to ice crusher.
1	0.333	1,000	Belted direct to one potato peeler.
1	0.333	870	Belted to one broiler exhaust.
1	1	1,750	Belted direct to dish washer.
1	1	1,750	Belted direct to one ice saw.
1	3	1,800	Belted direct to one 30-inch fan, for fresh air supply.
1	0.25	1,750	Direct-connected to one silver polisher.
1	3	1,000	Belted direct to one four-foot Sirocco exhaust fan.
1	3	1,200	Each connected by chain to one Sirocco four-foot exhaust fan.
2	0.333	1,250	110-volt motor direct-connected to telephone-booth exhaust fan.
2	3	1,720	Belted to line shaft driving one small compressor; one collar ironer; one collar dryer; one shirt edger; and one flat roll, 8 feet wide.

Motor Installation (Cont.)

The following is a list of the motors installed with their respective drives. The supply source is 220 volts direct current, and three phase, 60 cycle, 220 volt, alternating current.

No.	Horse-power	Speed R. P. M.	Application
1	10	1,720	Belted to line shaft driving three six-foot Troy washers; one three-foot Troy washer; and two 24-inch wringers.
1	3	1,140	Geared to one 48-in Troy mangle.
1	1	1,720	Belted direct to one 6 by 6-foot dry room.

PRINTING AND APPIED TRADES.

From the inception of commercially distributed electric power, the printing trades were among the first to apply it to meet their exacting requirements.The advantages of electric power may be summarized as follows:

The printing establishment employing central station power may be located in the most desirable business section of the town or city, where light, airy and easily accessible rooms are available, whereas, if a steam or internal combustion is used a combination of suitable location and adequate power is seldom obtainable.

The reliability of motor drive and the absence of belts etc. as well as the continuity of power supply from central station source is a very important item in the printing trade.

A certain degree of speed variation is required with printing and binding machinery owing to the great variety of the work performed. With electric drive these variations can easily be obtained and insure a maximum amount and quality of work with a given force of operatives.

The economy of space and the increased cleanliness of the shop due to the absence of shafting and belting is an important item in many cases.

Motor-driven presses closely approach theoretical conditions for maximum production.

The friction losses due to shafting and belting are done away with and a large amount of power is saved by the fact that the motor is running only when the press is in operation.

Other advantages are: Accident risks decreased in proportion to elimination of shafting, belting, etc.; closer and more accurate

Printing and Allied Trades, cont.

basis for determining productive costs; enlarged power capacity almost instantly available; economical handling of overtime work; practical freedom from fire risks; lower insurance rates.

Applications.

Paper Cutters,

1- 2 HP 1800 RPM motor driving 36" paper cutter.

1- 2 HP " " 48" Osage paper cutter.

1-1/4 HP " " 30" paper shears.

1- 3 HP " " 40" " "

1- 1 HP " " 30" " "

1- 2 HP 1150 RPM " " 45" Seybold cutter.

1- 5 HP 1200 RPM " belted to 44" Holyoke paper cutter.

1- 2 HP 1100 RPM " " " 34" Monarch " "

1-1.5 HP 1075 RPM " " " 36" " " "

1- 3 HP 1040 RPM " " " 44" Sheridan " "

1-1.5 HP 1400 RPM " " " 44" Brown & carver paper cutter.

1- 2 HP 1800 RPM " " " 36" paper cutter.

1- 3 HP 1800 RPM " " " 36" " "

1- 3 HP 1200 RPM " " " 36" Seybold paper cutter.

1- 2 HP 1150 RPM " " " 44" " " "

1- 5 HP 950 RPM " " " 60" " " "

1- 3 HP 1200 RPM " " " 48" Sheridan auto.paper cutter.

1- 1 HP 1175 RPM " " " 32" Perfection paper cutter.

1- 1 HP 1200 RPM " " " 30" Advance paper cutter.

1- 3 HP 1220 RPM " " " 44" White " "

1- 5 HP 980 RPM " " " 68" 20th Century Seybold paper cutter.

Printing and Allied Trades, cont.

Printing Presses.

1- 1/4 HP DC motor driving 8" x 10" Gordon press.
1- 1/2 HP DC " " 8" x 16" " "
1- 4 HP DC " " #3 Miehle press.1
1- 5 HP DC " " #4-0 " "
1- 3 HP 500 RPM motor driving #3 Miehle 2 roller press,
1- 5 HP 1850 RPM DC motor driving #3 Miehle 4 roller press.
1-1.5 HP 1100 RPM DC " " 34" " 2 roller pony press.
1- 1 HP 600 RPM DC " " 14" x 22" Colt armory press.
1- 1 HP 1350 RPM DC " " 10" x 15" " " "
1-1/2 HP 1500 RPM DC " belted to 10" x 15" Colt " "
1- 1 HP 1200 RPM DC " " " 11" x 17" Rotary Auto. "
1- 1 HP 1400 RPM DC " " " 15" x 18" Platen press.
1-2.5 HP DC " " " 24" x 36" Huber-Hodgeman
press.
1- 1 HP 1800 RPM AC " " " 8" x 12" Chandler Price press

Printing Presses, Cylinder.

RPM
1-7.5 HP 1200/AC motor belted to 16" x 28" cyl. press.
1- 5 HP 1800 RPM DC motor belted to 39" x 52" cyl. press.
1- 3 HP 1800 RPM DC " " " 28" X 42" " "
1- 4 HP 1950 RPM DC " " " 36" x 50" " "
1- 5 HP 1800 RPM DC " " " #3 Miehle 29" x 46" cyl.
press.
1- 5 HP 1800 RPM DC " " " #00 " 40" x 56" "
press.
1- 3 HP 1200 RPM DC " " " #3 " 29" x 44" " press
1- 3 HP 1200 RPM DC " " " #4 " 29" x 41" " "
1-1.5 HP 1125 RPM DC " " " " Pony " "
1- 3 HP 1800 RPM AC " " " " 52" " "
1- 2 HP 1500 RPM DC " " " Swink 25" x 38" " "

Printing and Allied Trades, cont.

Printing Presses, Cylinders, cont.

1-3.5 HP 1000-1260 RPM	motor	belted	to	Century 24" X 36"				cyl.	press.
1-3.5 HP 900-1175 RPM	"	"	"	#3 Miehle	29"x 44"			"	"
1- 5 HP 1100 RPM DC	"	"	"	#00000	"	65"		"	"
1- 4 HP 950 RPM DC	"	"	"	#00	"	56"		"	"
1- 5 HP 1100 RPM DC	"	"	"	#00	"	56"		"	"
1- 5 HP 1060 RPM DC	"	"	"	#000	"	62"		"	"
1- 4 HP 1080 RPM DC	"	"	"	#1	"	52"		"	"
1- 4 HP 1025 RPM DC	"	"	"	#00	"	56"		"	"
1- 3 HP 1100 RPM DC	"	"	"	#2	"	50"		"	"
1-1/2 HP 1480 RPM DC	"	"	"	12" x 15"			Platen	job	press.
1-1/2 HP 1800 RPM DC	"	"	"	8" x 12"			"	"	"
1-1/4 HP 1800 RPM DC	"	"	"	12" x 15"			"	"	"
1-1/4 HP 1800 RPM DC	"	"	"	8" x 12"			Gordon	"	"
1-1/4 HP 1850 RPM DC	"	"	"	1/2 Medium				"	"
1-1/2 HP 1165 RPM AC	"	"	"	12" x 15"			C & C	"	"
1-1/4 HP 1165 RPM AC	"	"	"	8" x 12"			C & C	"	"
1-1/2 HP 1600 RPM DC	"	"	"	8" x 12"			Gordon	"	"
1-1/2 HP 1600 RPM DC	"	"	"	10" x 15"			"	"	"
1- 1 HP 1200 RPM DC	"	"	"	14" x 22"			Thompson	"	"

Printing Presses (Newspaper)

1- 25 HP 750 RPM DC motor driving Goss Duplex, Cap. 30000 per hr.

1- 15 HP 1800 RPM AC " " " Acme 16 page newspaper press

1- 20 HP 800 RPM AC " " Howe 16 " " "

1- 35 HP 550 RPM DC " " Hoe 24" st. line p. " "

Other Machinery.

1-1/3 HP 1800 RPM AC motor geared direct to linotype machine.

Other Machinery, cont.

1- 1/2 HP 1200 RPM AC motor belted to linotype machine.

1- 1 HP 1200 RPM DC " " to 12 x 16 & 32 x 44 Dexter job paper folder.

1- 1 HP 600 RPM DC motor " to 32" x 44" paper folder.

PUMPS AND COMPRESSORS.

Pumping machinery is necessary in nearly every industry and in many, such as irrigation, water supply, sewage disposal, drainage, and fire-fighting equipment, it is very important. The adaptability of the electric motor to this class of machinery has long been recognized and many installations of both reciprocating and centrifugal pumps are seen in daily use and under some of the most trying conditions.

The initial cost of installation of a motor-driven pump is considerably less than that of a steam-driven pump. The location of a motor-driven pump need not have any relation to the source of supply of power while in a steam plant care must be taken not to have long lines of piping with its accompanying loss of energy. In mines where the passages are necessarily small, the transmission wires for a motor-drive pump can be handled with little difficulty while with steam special shafts might be required.

Pumps
Power Requirements.

The driving power required by a centrifugal pump will vary directly with the product of the capacity and the head. It will be of assistance in this connection to consider a concrete example the conditions of which are as follows: Capacity, 800 gal/min; static suction 5 ft.; suction pipe 25 ft. long, 6" diam., one 90 degree bend; static discharge head, 34 ft. discharge pipe, 300 ft. long 6" diam., one 90 degree bend; current 60 cycle, three phase, 220 volts. The total static head is 39 ft. Adding 21 ft. for

Pumps, cont.

friction and velocity (determined from hand-book tables, using the pipe dimensions as a basis) the total net head amounts to 60 ft. The pump manufacturer finds that a 6" single stage, double suction pump will fill the requirements very nicely and guarantees an efficiency of 70%. The horse-power is then obtained by the use of the following formula:-

$$\text{Brake horse-power} = \frac{\text{Gal. per min. x head in ft.}}{\text{3960 x eff.}} = 17.3$$

From this it is evident that a 20 HP motor should be used, as it is the nearest commercial size.

Pumps and Compressors
Applications.

1- 75 HP motor driving Fairbanks-Morse vert.cent.pump, cap. 3000-4000 gal/min.

1-300 HP RPM motor dir. con. to 6-stage, 1000 GPM centrifugal pump.

1-170 HP 300-450 RPM motor geared to 10" Quintuplex pump with 400' head.

1-1000 HP 720 RPM motor dir. con. to 5000 GPM, 6-stage cent. pump with 500' head.

1-150 HP 700-1200 RPM motor DC. to 4-stage, 10" cent. 330' head, 1000 GPM.

1-150 HP motor driving cent. pump rated 2000 GPM, 125' head.

1- 75 HP KV-A 1200 RPM syn. motor driving 1200 GPM, 2-stage cent. with 160' head.

1-100 HP 750 RPM motor driving 5000 GPM, 1-stage cent. pump against 50' head.

Pumps Centrifugal.

1- 5 HP 800 RPM AC motor cent. circulating pump.

1-7.5 HP 1200 RPM AC " dir. con. to 4" Wheeler cent. pump.

1- 25 HP 900 RPM AC " belted to 6" cent. pump.

1- 25 HP 1800 RPM AC " dir. con. to 8" Rolter cent. pump.

1-7.5 HP 1200 RPM AC " " " " cent. pump, Cap. 750,000 gal/day.

Pumps & Compressors, Cont.

1- 20 HP 900 RPM AC motor dir. con. to cent. pump, Cap. 1500 gal/min.

Centrifugal Sand.

1- 50 HP 1800 RPM AC motor belted 8" 600 RPM cent. sand pump. L.F.2.9%.
1- 75 HP 900 RPM AC " " 8" " " " L.F. 14%

Plunger pumps.

1- 100 HP 690 RPM AC motor geared to 10" x 12" Hor. Duplex outside cent. packed pump, Cap. 700 gal/min. against head at 45 RPM.
1- 35 HP 720 RPM AC motor geared to 9.5" x 15" Triplex single acting pump, Cap. 495 gal/min., pressure 185#, 39 RPM, Av.L.F. 26%.

Pumps & Compressors, cont.
Applications.

Lawrence Centrifugal Pumps, Class B- For lifts from 15 to 35 ft.

No.	Suction pipe, in.	Discharge pipe, in.	Economical Cap. gal. per min.	HP for each FT. of lift.
1	1.5	1	25	,028
1.5	2	1.5	70	.05
2	2.5	2	100	.08
3	3.5	3	250	.15
4	4.5	4	450	.27
5	6	5	700	.36
6	6	6	1200	.65
8	8	8	2000	1.10
10	10	10	3000	1.60
12	12	12	4200	2.15
15	15	15	7000	3.50
18	18	18	10000	5.00
24	24	24	18000	7.60
30	30	30	25000	10.50
36	36	36	35000	14.75

Note: The economical capacity corresponds to a flow not exceeding 10 ft. per second in the delivery-pipe. Small pipes and high rate of flow cause a great loss of power.

Pumps & Compressors, cont.
Applications.

Water Pumps.

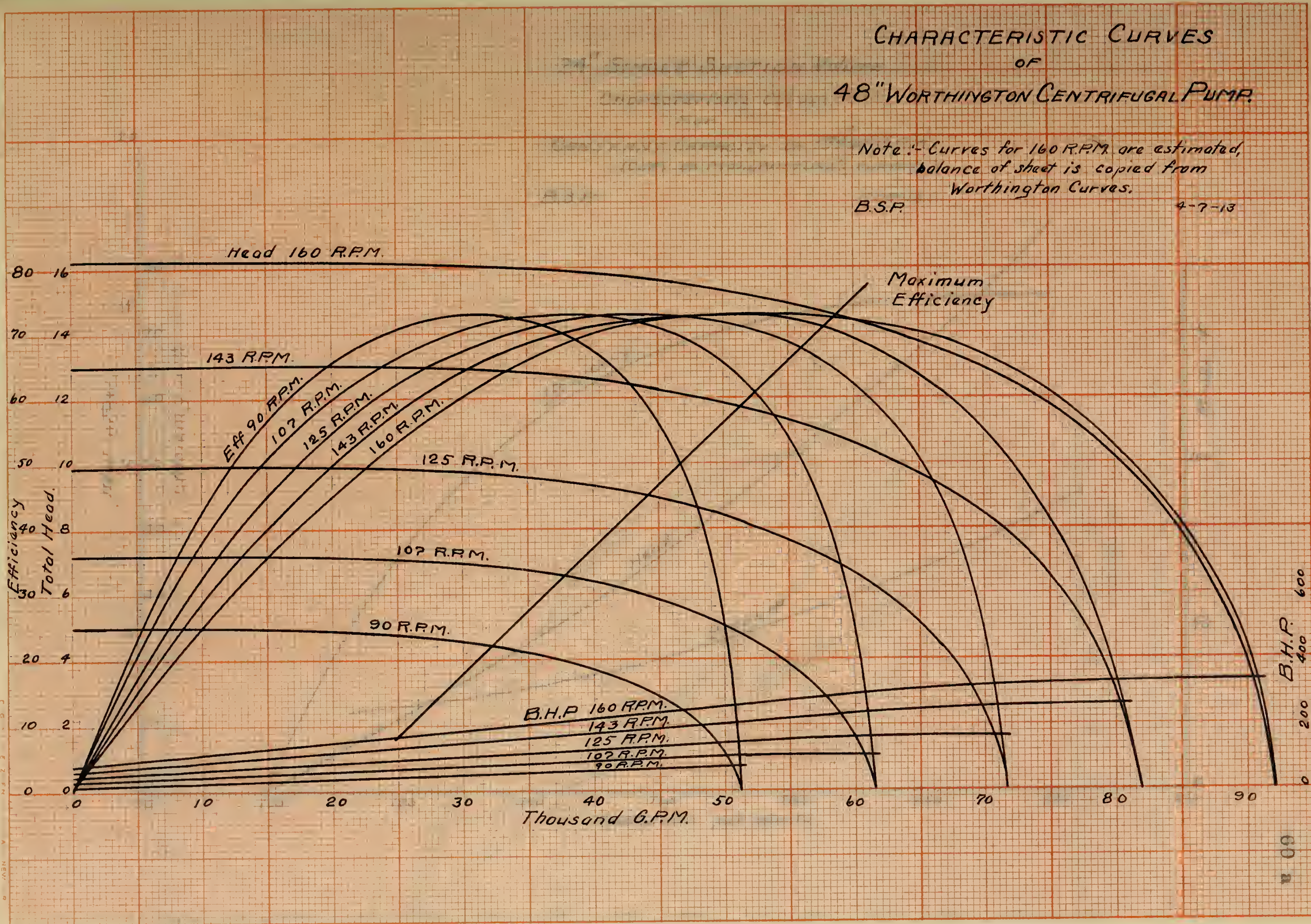
1- 7.5 HP 900 RPM AC motor geared to 90 gal/min. hot or cold water pump.
1- 4.5 HP 900 RPM AC " " " 50 " " " " " water pump.
1- 3 HP 1200 RPM AC " " " Ice water circulating pump.
1- 10 HP 1200 RPM DC " chained " Triplex pump, Cap. 144 gal/min.
1- 7.5 HP 2400 RPM DC " belted " 2.5"x 2" Alberger pump.
1- 40 HP 1200 RPM AC " dir.con." 10"x12" Deane. Cap. 204 gal/min, 25 strokes.
1- 40 HP 1800 RPM AC " " " " 5", 3-stage cent. Cap. 500 gal/min. 225' head.
1- 20 HP 900 RPM AC motor " " " 7" x 8" Deane triplex, Cap. 180 gal/min. 45 strokes.
1- 15 HP 1800 RPM AC motor dir. con. to pump, Cap. 80000 to 100000 gal/day.

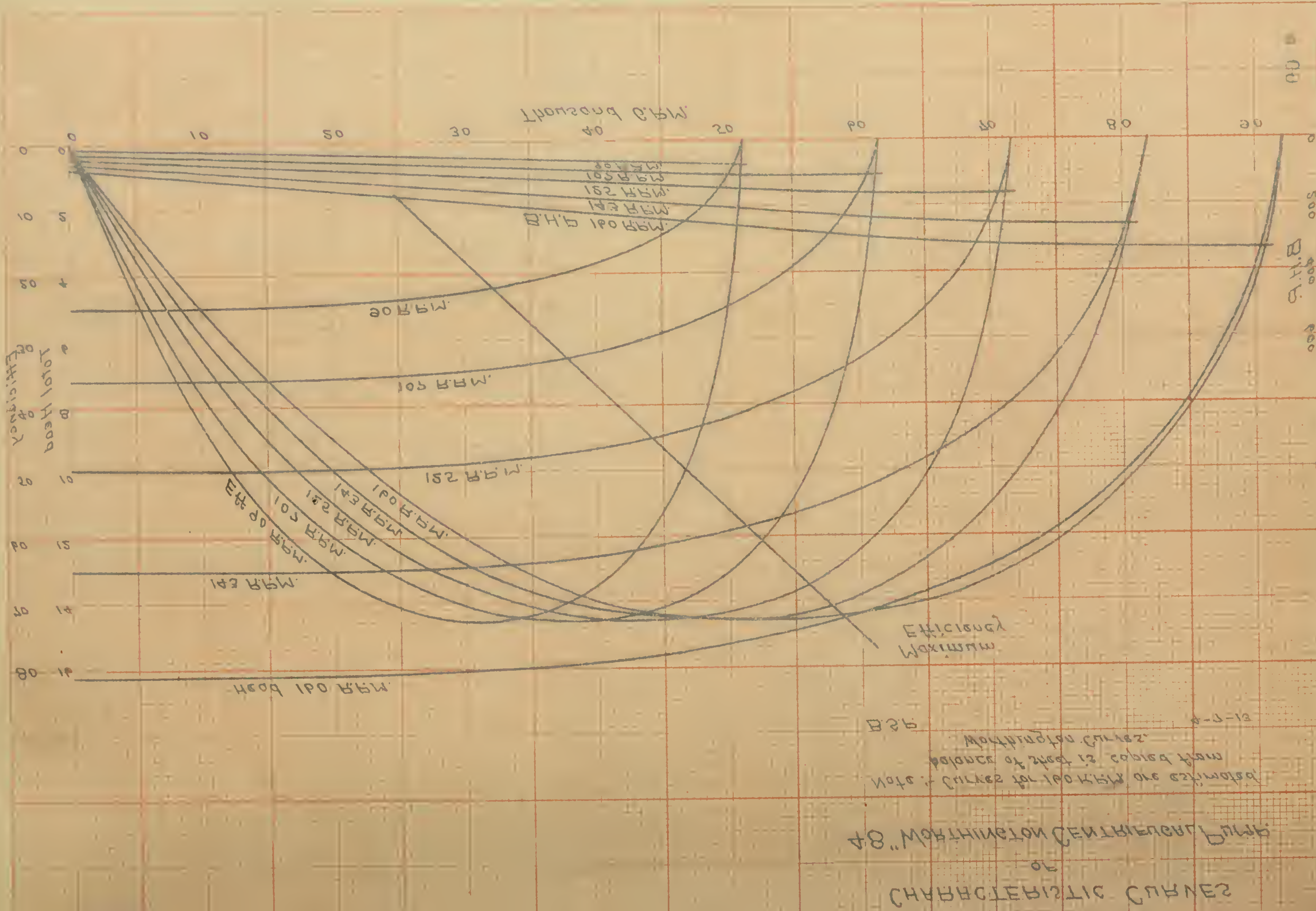
Approximate General Dimensions, Weights, Speeds, Etc.
Air Compressors

	D C	D C	A C	D C	A C	D C	A C	D C	A C
Piston displacement, cu. ft. per min.	15	25	25	35	35	50	50	100	100
Max.press.lbs.per sq.in.	90	90	90	90	90	90	90	135	135
Voltage	(600 (250 (125	600 250 125	550 440 220 110	600	550 440 220 110	550 250	550 440 220 110	600	550 440 220 110
Cylinder diam. in.	4-1/8	4 3/4	4 3/4	5 1/2	5 1/2	7 3/4	7 3/4	(10 1/4 (5 3/4	10 1/4 5 3/4
Stroke, inches	4-7/8	6	6	7	7	5	5	6	6
R.p.m. compressor	200	203	203	182	182	183	183	175	175
R.p.m. motor	1094	1110	(#750 (*1200 (‡1200	1027	#750 *800 ‡900	1100	#750 *800 ‡900	723	#750 *800 ‡900
Approx. kw.input	2.5	4.2	4.5	6	6.3	8.8	9	19	20

\# Synchronous speed of 25 cycle induction motor.
* Synchronous speed of 40 cycle induction motor.
‡ Synchronous speed of 60 cycle induction motor.

In cases where the d.c. operating voltages vary from the listed voltage within 10%, the piston displacement will vary in direct proportion.


CHARACTERISTIC CURVES
OF
48" WORTHINGTON CENTRIFUGAL PUMP.
Note:- Curves for 160 R.P.M. are estimated, balance of sheet is copied from Worthington Curves.
B.S.P.
4-7-13
Head 160 R.P.M.
143 R.P.M.
125 R.P.M.
107 R.P.M.
90 R.P.M.
Eff 90 R.P.M.
107 R.P.M.
125 R.P.M.
143 R.P.M.
160 R.P.M.
Maximum Efficiency
B.H.P. 160 R.P.M.
143 R.P.M.
125 R.P.M.
107 R.P.M.
90 R.P.M.
Efficiency
Total Head.
B.H.P.
Thousand G.P.M.
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
16
200
400
600

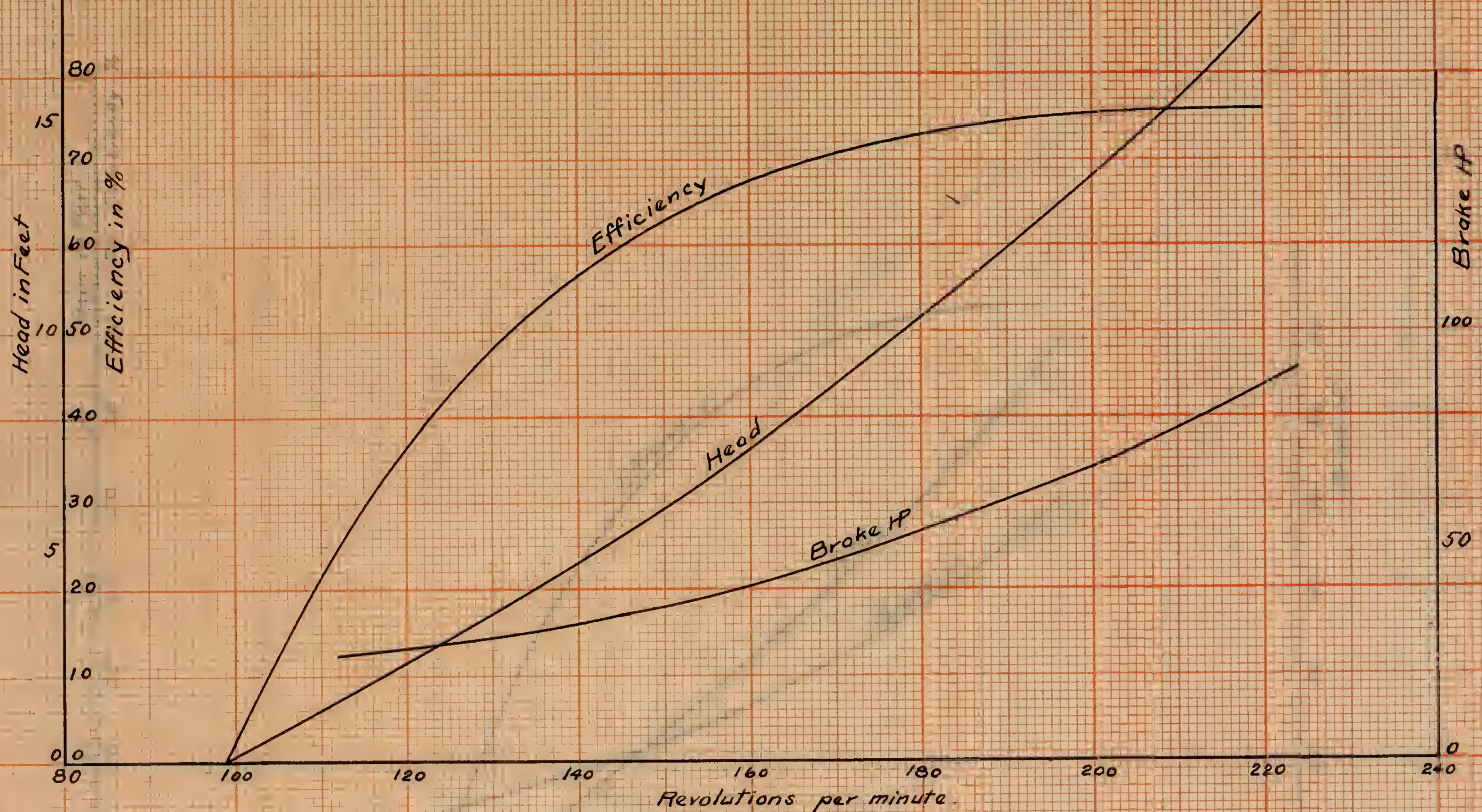


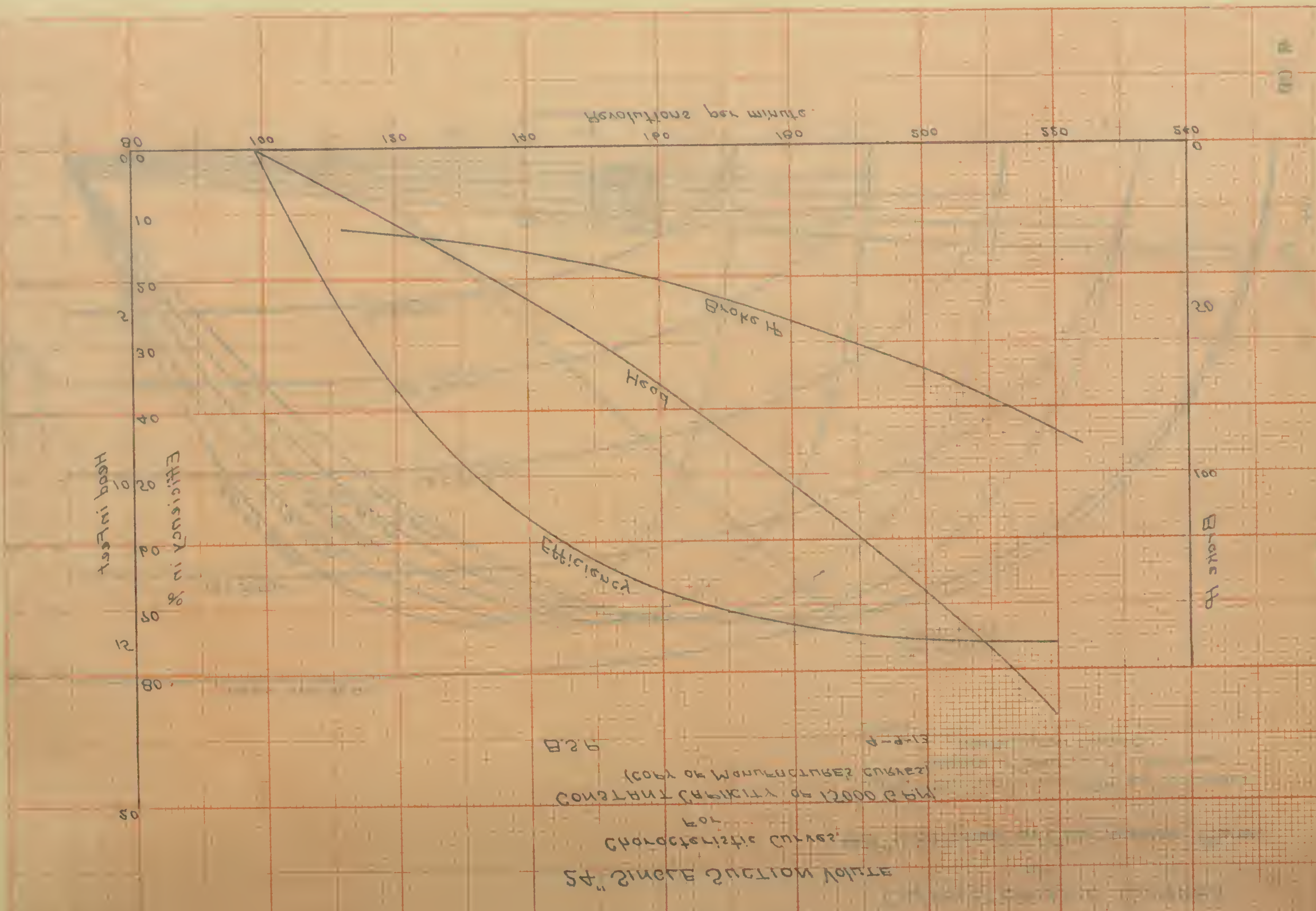
CHARACTERISTIC CURVES
of
48" Worthington Centrifugal Pump
Note: Curves for 160 R.P.M. are estimated; balance of sheet is copied from Worthington Curves.
B.S.P.
Thousand G.P.M.
B.H.P.
Total Head
Efficiency
B.H.P. 160 R.P.M.
143 R.P.M.
125 R.P.M.
102 R.P.M.
90 R.P.M.
Eff 90 R.P.M.
102 R.P.M.
125 R.P.M.
143 R.P.M.
160 R.P.M.
Head 160 R.P.M.
Maximum Efficiency

24" SINGLE SUCTION VOLUTE

Characteristic Curves
For
CONSTANT CAPACITY OF 15000 G.P.M.
(COPY OF MANUFACTURE'S CURVES)

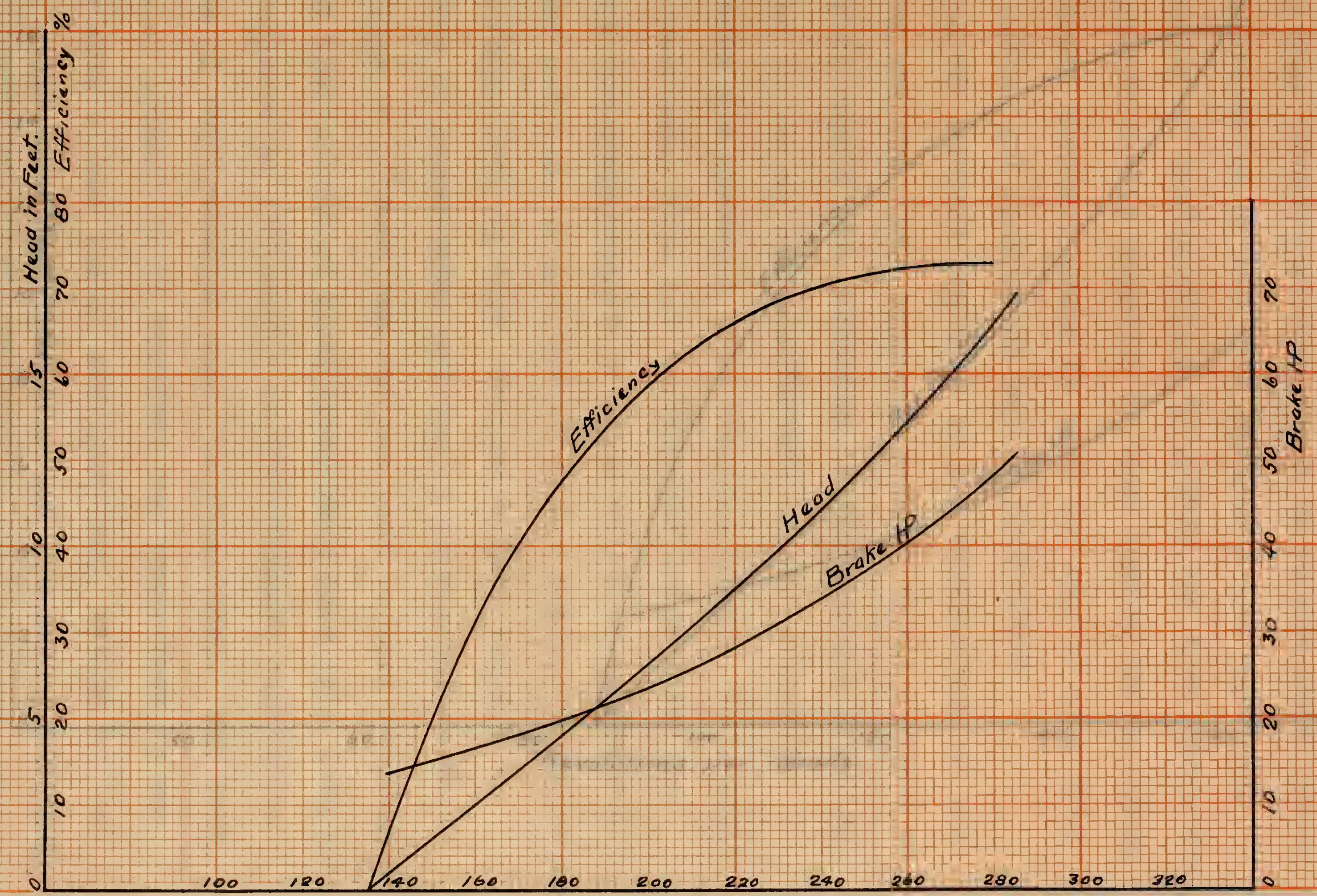
B.S.P. 4-9-13




24" Single Suction Volute
Characteristic Curves
For
Constant Capacity of 15000 G.P.M.
(copy of Manufacturers curves)
B.S.P.
4-4-13
Revolutions per minute
Head in Feet
Efficiency in %
Brake H.P.
Head
Efficiency

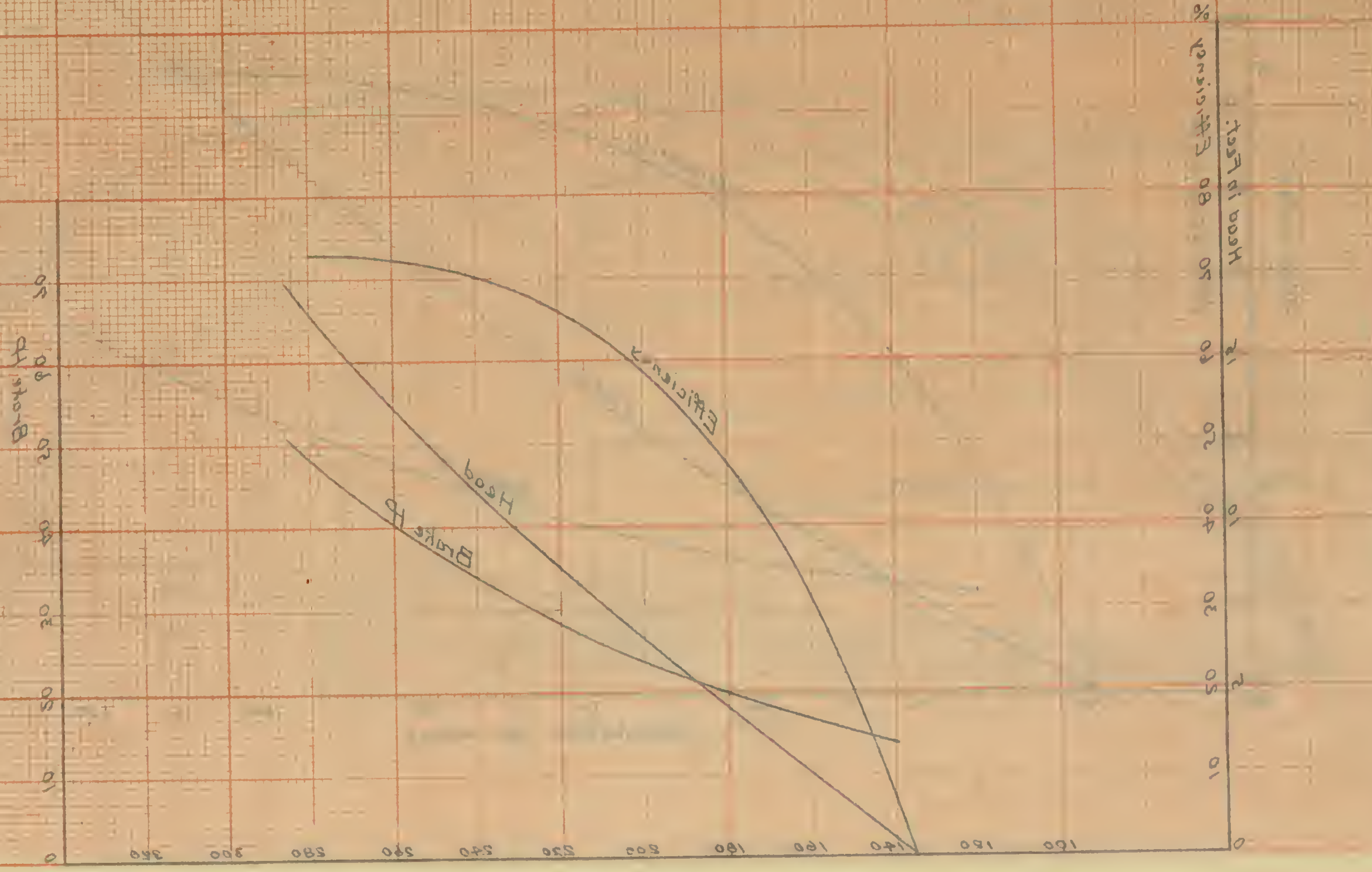
"18" Single Suction Volute Pump.
Characteristic Curves
For
Constant Capacity of 8400 G.P.M.
(Copy of Manufacturer's Curves)

B.S.P. 4-9-13



18" Single Suction Volute Pump
Characteristic Curves
For
Constant Capacity of 8400 G.P.M.
(Copy of Manufacturers Curves)

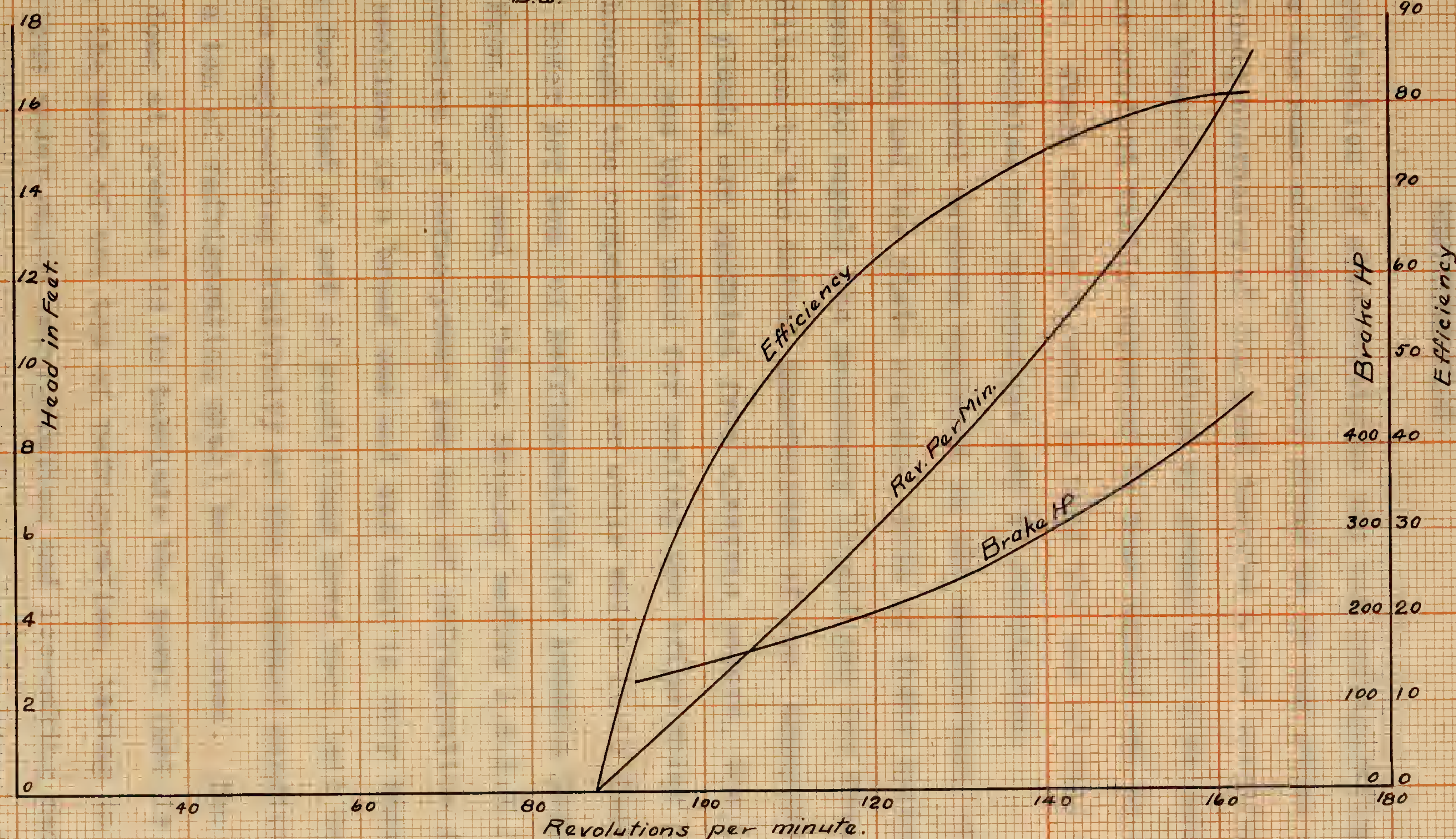
B.S.P. 4-9-13

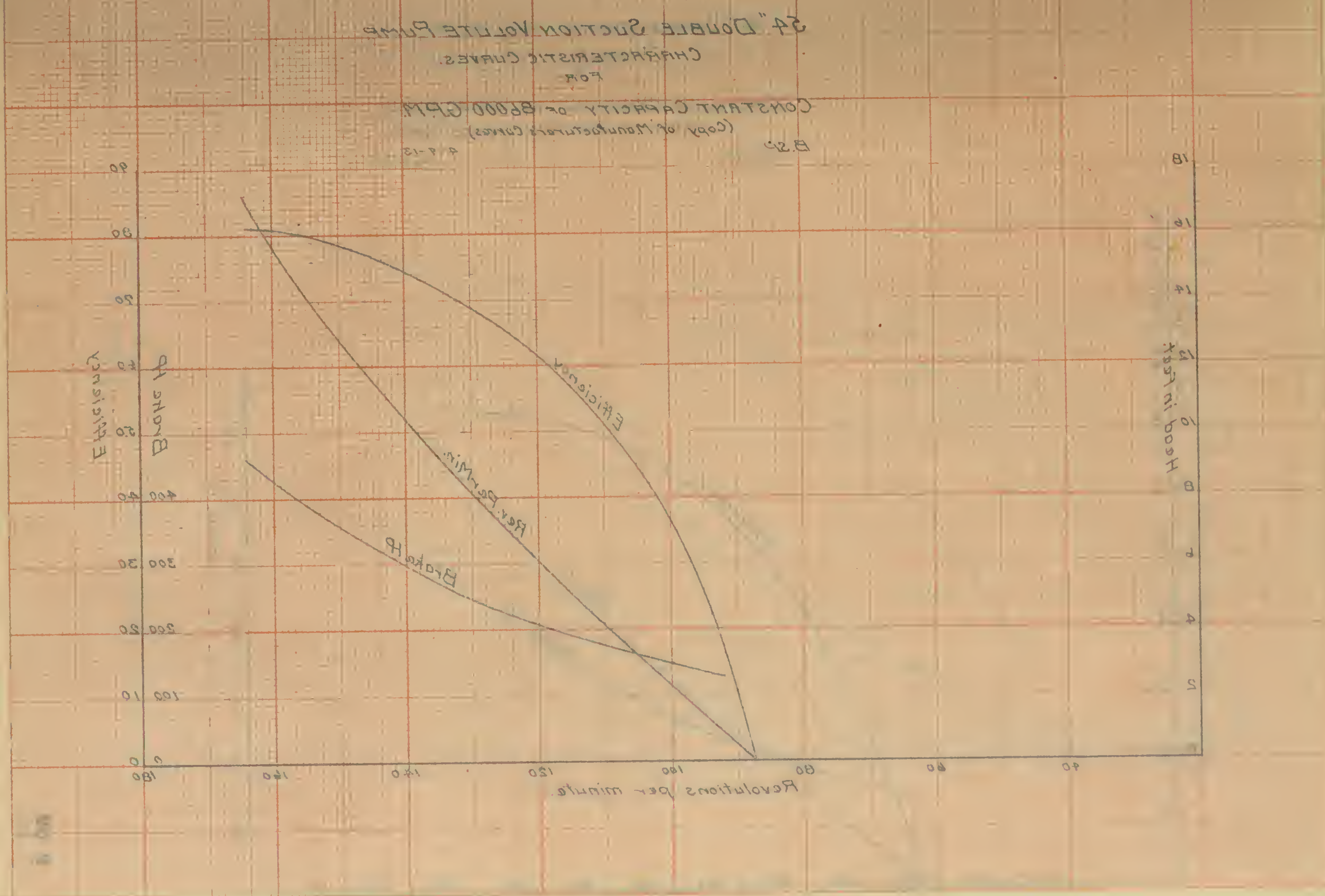


54" Double Suction Volute Pump.

Characteristic Curves.
For
Constant Capacity of 86000 G.P.M.
(Copy of Manufacturer's Curves)

B.S.P. 4-9-13




34" Double Suction Volute Pump
Characteristic Curves
for
Constant Capacity of 86000 G.P.M.
(Copy of Manufacturers Curves)
B.S.P.
Efficiency
Rev. Per Min.
Brake H.P.
Head in Feet
Revolutions per minute
Brake H.P.
Efficiency

REFRIGERATION.

The application of electricity to ice and refrigerating plants offers the same advantages over steam as in any other industry. The steady character of the load insures a low operating cost, and the absence of contamination by grease and dirt makes the quality of the product vastly superior to that turned out by steam driven plants. Where electric power is used the use of coal with its attendant troubles and annoyances may be eliminated.

The two general methods employed in the manufacture of ice are the can system and the plate system. Both of these systems require compressors to supply the necessary liquid gas for freezing.

In addition to the actual manufacture of ice, numerous refrigerating plants are operated from electric motors, the liquid ammonia or other gas being used for cooling the brine which is circulated through the compartments or coils which it is desired.

Horse Power per ton of Refrigeration for Ammonia Compression Machines. (From Paper read by Thos. Shipley before A.S.R.E.)

The question of horse-power per ton of refrigeration for compression machines is a broad one and one that is very indefinite, owing to the fact that no set of conditions have been laid down and adopted by the engineering fraternity as the standard conditions under which a ton of refrigeration shall be calculated. The best that can be done at present is to tabulate the power that is required to do the work of one ton of refrigeration, taking in the usual conditions under which refrigeration and ice-making machines operate. Then with suction and condensing pressures given, together with the condition under which the compressor is to be operated,

the capacity of the compressor and the horse-power per ton can be determined with reasonable accuracy. An idea of the range of such a table can be had by reference to a table published by one of the manufacturers, shown in Table I.

TABLE I.

Horse-Power Required to Produce One Ton of Refrigeration.

Condenser Pressure and Temperature.

P.	P.	103.	115	127	139	168	168	184	200	218
P.	T.	65°	70°	75°	80°	85°	90°	95°	100°	105°.
4	20°	1.0584	1.1304	1.2051	1.2832	1.3611	1.4427	1.5251	1.6090	1.6910
6	15°	.9972	1.0692	1.1450	1.221	1.3001	1.4101	1.4609	1.5458	1.63
9	10°	.9026	.9777	1.0453	1.1183	1.1926	1.2602	1.3471	1.4352	1.5093
13	5°	.8184	.8833	.9537	1.0230	1.0935	1.1679	1.2437	1.3209	1.3964
16	0°	.7352	.8008	.8648	.9328	1.0019	1.0718	1.1467	1.2194	1.2547
20	5°	.6665	.7312	.7946	.8593	.9278	.9978	1.0656	1.1381	1.2121
24	10°	.5915	.6629	.7257	.7894	.8545	.9205	.9911	1.0595	1.1294
28	15°	.5410	.5998	.6641	.7276	.7924	.8553	.9224	.9943	1.0603
33	20°	.4745	.5340	.5923	.6716	.7148	.7796	.8420	.9031	.9736
39	25°	.4103	.4659	.5227	.5804	.5992	.7022	.7667	.8289	.8922
45	30°	.3509	.4056	.4612	.5178	.5755	.6353	.6944	.7590	.8172
51	35°	.3005	.3546	.4101	.4666	.5214	.5804	.6398	.7009	.7629

Note. - The figures in this table represent the minimum theoretical amount. In practice they must be increased about 50 per cent.

The above table represents the minimum theoretical power utilized in a compressor to compress sufficient ammonia gas, which, when liquified at the pressure stated, will, upon being evaporated from the temperature correspomding to said pressure to the temperature corresponding to the pressure in the evaporating system, do the same amount of work as is done by the melting of one ton of ice. In other words the assumption is that the compressor is working at 100% efficiency that is, dry compression without any loss from superheating, clearance or any other cause. It is necessary to know the actual efficiency of a compressor before the horsepower per ton can be calculated.

The following table is based on tests the York Mfg. Co., run with its plant in York, Pa., and it gives the efficiency, displacement and compressor horsepower per ton of refrigeration for both single and double acting machines for several condencing and suction pressures.

TABLE II

DISPLACEMENT AND HORSE-POWER PER TON OF REFRIGERATION. YORK MANUFACTURING COMPANY'S SINGLE ACTING AND DOUBLE ACTING COMPRESSORS. DRY COMPRESSIONS.

Suction Gauge Pressure and Corresponding Temperatures.

		5 lbs. = 17.5° F.			10 lbs. = 0° F.			15.67 lbs. = .0° F		
Condenser gauge press. and corres. temp. = Temp. of liquid at expansion valve.		Volumetric efficiency per cent of displacement	Cu. In displacement per min. per ton of refrigeration.	I. H. P. per ton (compressor).	Vol. eff	Cu. In. disp.	I. H. P. per ton (compressor)	Vol. eff.	Cu. In. Disp	I. H. P. per ton (compressor).
145 lbs. = 82° F.	S. A....	79.	12,608	1.654	81.2	9,811	1.4	83.	7,829	1.195
	D. A....	68.	14,645	1.921	70.5	11,300	1.612	73.	8,901	1.358
165 lbs. = 89° F.	S. A....	77.5	13,045	1.834	79.7	10,148	1.56	81.5	8,092	1.341
	D. A....	66.5	15,203	2.137	69.	11,720	1.802	71.5	9,224	1.529
185 lbs. = 95.5° F.	S. A....	76.	13,491	2.013	78.2	10,487	1.72	80.	8,362	1.4865
	D. A....	65.	15,774	2.354	67.5	12,150	1.993	70.	9,555	1.7
205 lbs. = 101.4° F.	S. A....	74.5	13,947	2.192	76.7	10,834	1.879	78.5	8,630	1.631
	D. A....	63.5	16,362	2.571	66.	12,590	2.184	68.5	9,890	1.87

(Cont. of Table II - Refrigeration

Condenser gauge press. and corres. temp. = Temp. of liquid at expansion valve.		20 lbs. = 5.7° F. Volumetric efficiency per cent of displacement.	20 lbs. = 5.7° F. Cu. In. displacement per min. per ten of refrigeration.	20 lbs. = 5.7° F. I. H. P. per ton (compressor)	25 lbs. = 11.5° F. Vol. eff.	25 lbs. = 11.5° F. Cu. In. disp.	25 lbs. = 11.5° F. I. H. P. per ton (compressor)
145 lbs. = 82°F.	S. A.	84.2	6,765	1.065	85.5	5,836	.943
	D. A.	74.7	7,625	1.2	76.5	6,522	1.054
165 lbs. = 89° F.	S. A.	82.7	6,990	1.201	84.	6,027	1.071
	D. A.	73.2	7,898	1.357	75.	6,751	1.2
185 lbs. = 95.5° F.	S. A.	81.2	7,219	1.336	82.5	6,223	1.197
	D. A.	71.7	8,176	1.513	73.5	6,985	1.344
205 lbs. =101.4°F.	S. A.	79.7	7,450	1.47	81.	6,420	1.323
	D. A.	70.2	8,459	1.67	72.	7,222	1.488

Note. - The above table represents the efficiencies and displacements where the clearance does not exceed 1/32 in.

Unless the clearance is excessive no addition to the horse-power will be necessary.

Where liquid is cooled lower than temperature corresponding to condensing pressure, there will be a reduction in horse-power and displacement proportional to the increase of work done by each pound of liquid handled.

For engine horse-power add 17 per cent, to the compressor horse-power up to 20 tons capacity and 15 per cent for larger machines.

This table is based on tests made before January 1st, 1906.

Refrigeration.

Capacities of Ice Machines and Horse-power required.
(Based on condensing water of a temperature of 70 degrees F)

Refrigerating Capacity in tons per 24 hours.	Ice-making Capacity in tons per 24 hours.	Horse-power required.
0.5	0.25	1
1	0.5	2
2	1	4
3	1.5	6
5	2.5	9
8	4	13
10	5	15
12	6	17
16	8	22
20	10	26
25	12.5	32
30	15	37.5
35	17.5	43
40	20	48
50	25	60

Refrigeration, cont.

1- 5 HP 1800 RPM AC motor driving 1 ton Rumington Ice Machine.

1- 6 HP 900 RPM AC " " 2.5 " Ice Machine.

1- 35 HP motor belted to 25 ton Linde Ice Machine. Av.L.F. 23%.

1- 2 HP 1800 RPM AC motor driving 1-ton Armstrong Ref. machine. L.F. 27.5%.

1- 35 HP 900 RPM AC " belted to 15" Linde Ice Machine (19 boxes

1- 10 HP 1400 RPM DC " driving 7-ton Althoff " " Av. L.F. 19.4%.

1- 50 HP 514 RPM AC " " 25-ton Vilter " " Av. L.F. 16.1%.

1- 13 HP 650 RPM DC " belted to 7-ton Refrigeration Machine. L.F. 20.7% .

1- 15 HP 1200 RPM AC " " to 7-ton " " L.F. 17%.

1- 5 HP 1800 RPM DC " " to 3-ton Jones Compressor. L.F. 19.7%.

1- 30 HP AC " " to 40-ton Ice Machine. Av.L.F. 24.4%.

1- 25 HP AC " " to 40-ton " " Av. L.F. 24.4%.

1- 35 HP DC " " to 40-ton " " Av. L.F. 24.4%.

1- 10 HP 800 RPM DC " chained to 7-ton Ref. Machine Av. L.F. 27.6%.

1- 2 HP 1800 RPM AC " belted to 2-ton Anderson Comp. Av. L.F. 20.6%.

1- 15 HP 560 RPM DC " " " 10-ton Larson Baker Comp. Av. L.F. 40.8%.

1- 30 HP 600 RPM DC " " " 20-ton " " " Av. L.F. 22.2%.

1-7.5 HP 900 RPM AC " " " 6.5-ton Wolf Compressor

1-7.5 HP 1800 RPM AC " " " 4-ton Refrigerating Machine.

1- 20 HP 720 RPM AC " " " 15-ton Racine Ref. Machine. Av. L.F. 30.6%.

1- 5 HP 1800 RPM AC " " " Deming Triplex Circ. Brine Pump.

1- 12 HP 675 RPM DC " " " 6-ton Rebsaneb Comp. Av. L.F. 17.9%.

1- 35 HP 400-800" DC " " " 20-ton Kroeshall "

1- 18 HP 625 RPM DC " " " 10-ton " "

1- 20 HP DC " " " 15-ton Barber "

1- 10 HP DC " " " 6-ton " "

POWER REQUIREMENTS OF ROLLING MILLS, (From W. Sykes)

The subject is one of great complexity due to the various factors controlling power requirements and also to the variations in operating conditions in different works. The subject of rolling mills is one on which it is hardly possible to obtain reliable information from published data and the whole rolling mill practice is based on empirical knowledge gained by experience.

It will not be attempted to give any set of rules for determining the correct size and characteristics of the motor for driving any particular mill but rather to indicate the lines along which such problems must be studied and to give an idea of the factors controlling the size and equipment required. Even with full knowledge of the conditions, considerable judgement is always required in working out such problems.

In the first place, the size of the mill as determined by the size of the pinions or the width and diameter of the rolls has comparatively little to do with the size of motor required to drive it as the work performed by the same size mill may vary several hundred per cent. The fundamental basis on which the size of motor must be determined, is the product of the mill and the tonnage rolled. There are a great many other factors entering into the proposition which must be considered and dealing first with the product, the following are the principal in their usual order of importance:-

1. Volume of metal displaced.
2. Method of displacement.
3. Temperature of the metal.
4. Class of material.

5. Rate of displacement.

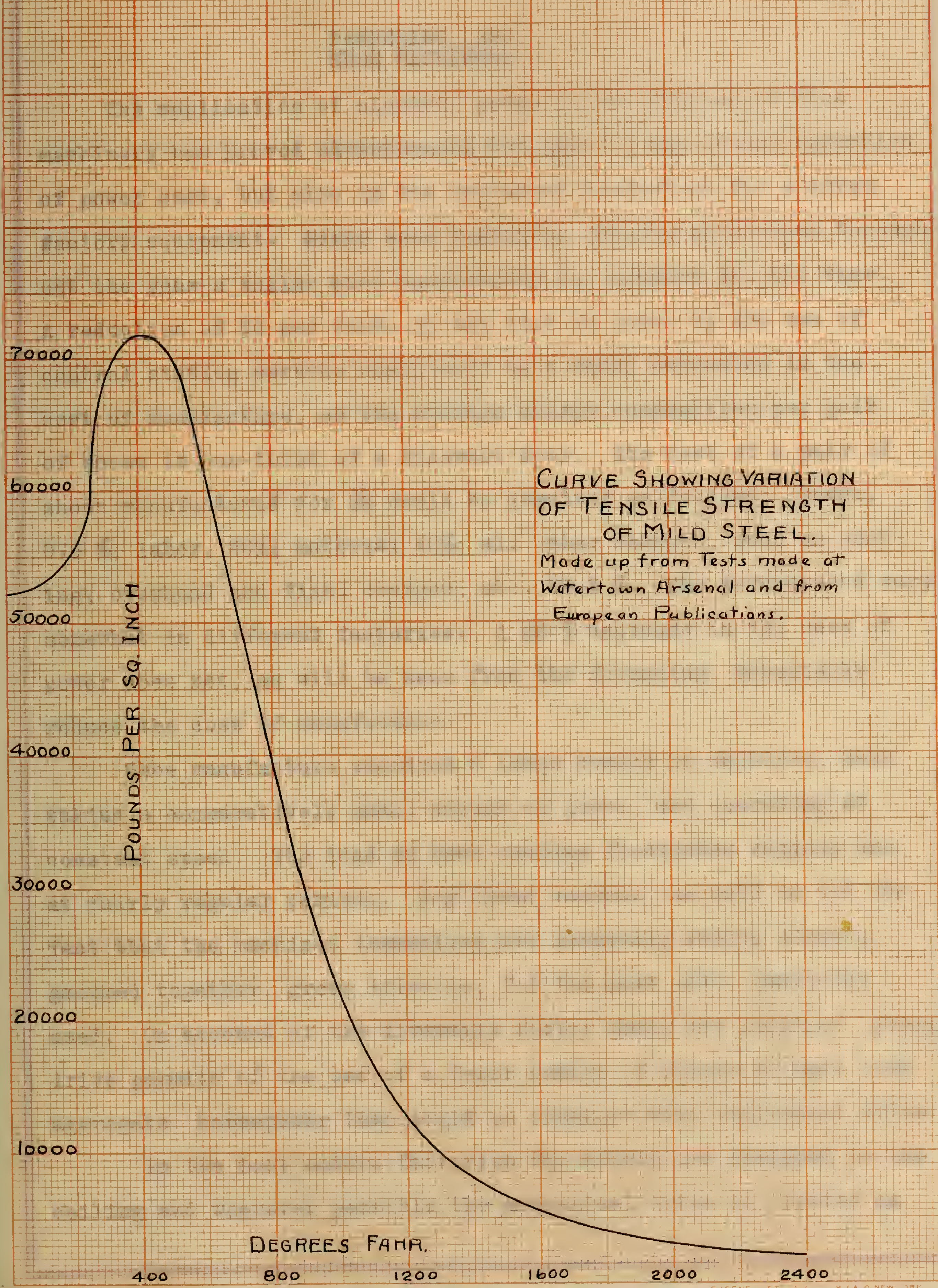
6. Size of roll.

In the first two cases it can readily be seen how important they are but authorities do not agree and data is not at hand to give any direct bearing on the subject. The temperature of the metal plays an important part in the power requirements. It has been indicated from tests that other things being equal, the power requirements vary practically as the tensile strength of the material. The accompanying curve shows that the strength increases quite rapidly after the temperature drops below 1400 degrees so that in rolling thin sheets the power requirements increase at a very rapid rate.

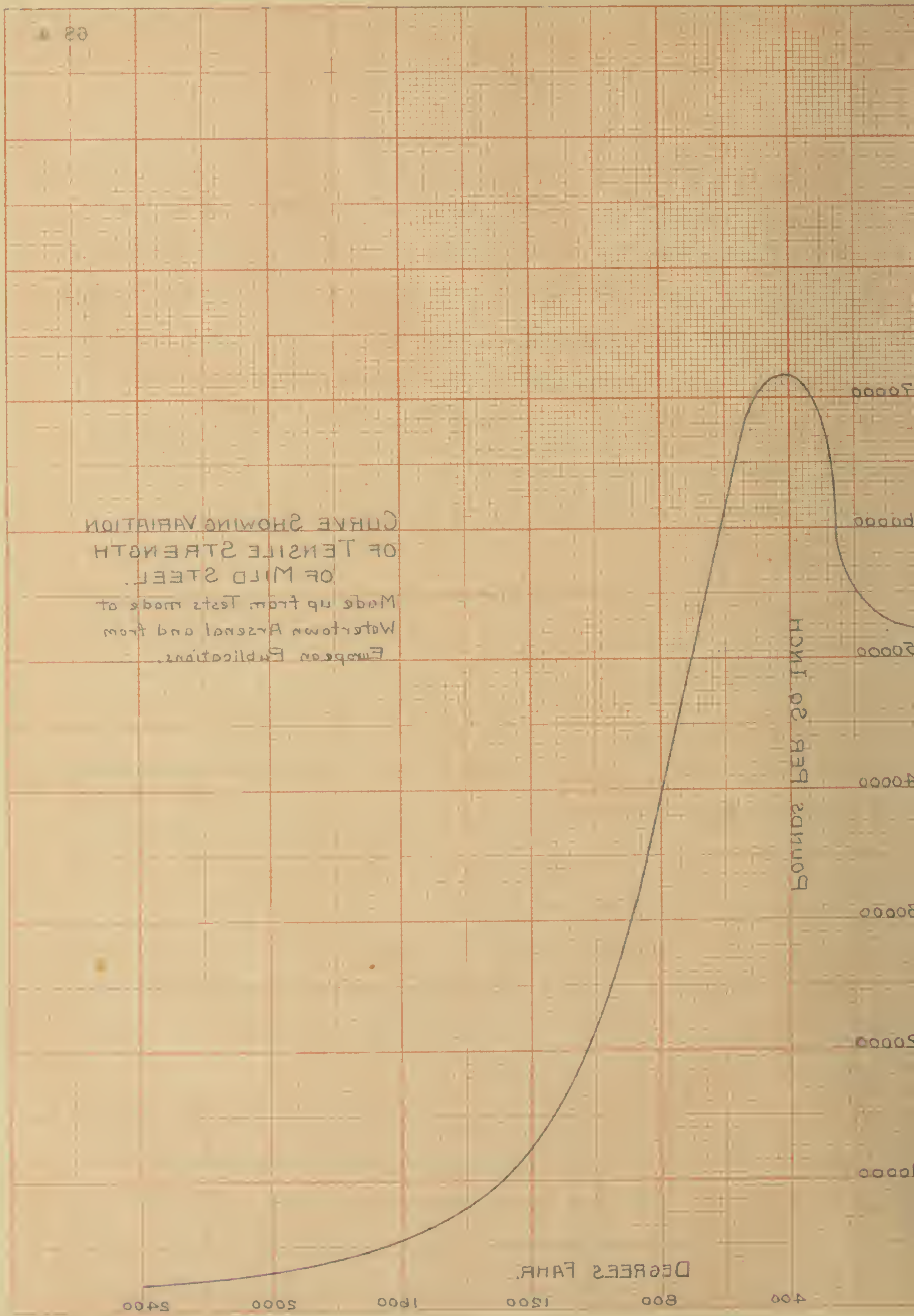
As to the class of material it is found from tests that providing the temperature is the same, the power required to displace a given volume of metal, is practically independent of the chemical composition of the steel. Indirectly though it has considerable influence, as it is necessary to roll high carbon steels at comparatively low temperatures so that the power consumption for a given volume of displacement may be much higher than would be the case when rolling mild steel.

As to the last two factors, it appears that although they are not of much importance, they exert some influence. A low rate of displacement requires a somewhat lower power and also small rolls should require less power.

From the above discussion it can be seen that a theoretical determination of the power required to drive a certain mill is very uncertain as yet and the only practical way to arrive at this determination is to use previous installations as a basis for final calculation.



CURVE SHOWING VARIATION OF TENSILE STRENGTH OF MILD STEEL.
Made up from Tests made at Watertown Arsenal and from European Publications.
POUNDS PER SQ. INCH
70000
60000
50000
40000
30000
20000
10000
DEGREES FAHR.
400
800
1200
1600
2000
2400


CURVE SHOWING VARIATION
OF TENSILE STRENGTH
OF MILD STEEL.
Made up from Tests made at
Watertown Arsenal and from
European Publications.
POUNDS PER SQ INCH
70000
60000
50000
40000
30000
20000
10000
DEGREES FAHR.
400
800
1200
1600
2000
2400

TANNERIES, ETC.
SHOE MACHINERY.

The application of electric power to the driving of shoe machinery has proved advantageous not only in the direct reduction of power cost, but also in the increased production for a given factory equipment. Since shoe factories require live steam throughout the year a boiler must necessarily be operated all the time. A reduction of 25 per cent. in the cost of power by the use of central station service would only be a small reduction in the cost of manufacture, as the average energy consumption per pair of shoes is one-third of a kilowatt-hour. The cost of a pair of shoes manufactured for $2 could be itemized as follows: power, 0.5 %; labor, 20%; material 40%; all other charges, such as heating, overhead and fixed charges, etc. 39.5 %. The percentages vary somewhat in different factories. A 25 % decrease in the cost of power does not, as will be seen from the foregoing, materially reduce the cost of manufacture.

Shoe manufacture requires a large number of machines, each taking a comparatively small amount of power, and operating at constant speed. The load on each machine fluctuates rapidly and at fairly regular periods. For these reasons, as well as for the fact that the machines themselves are naturally rather closely grouped together, group drive is, for the most part, generally used. On account of the diversity factor among the machines, group drive permits of the use of a fewer number of motors of much less aggregate horsepower than could be obtained with individual drive.

In the most modern factories the motors are fastened to the ceiling and wherever possible the mechanical drive is located on

the floor below the driven machines. The elimination of numerous belts between overhead shafting and the machines makes a safer and cleaner installation, permits of better arrangement of machinery, and the most economical use of space. As the shafting operating the machines in the fitting department is located beneath the tables on which they are placed, the most compact and best type of drive is that of a motor placed on the floor and direct-connected to the shafting. Motors for use on either direct or alternating-current, and running at from 400 to 500 RPM are largely used for this class of work.

The accompanying table gives the actual horse-power input required to operate each machine. The size motor needed to drive a group of these machines depends on the load factor and the amount of shafting. The load factor of the average group of machines will vary from 25 to 75 per cent., depending on the routing of material, ease of operation, and condition and general layout of the machines themselves.

Horsepower Input to Shoe Machinery.

	Horsepower.
Goodyear rapid stitching machine	0.4
Atlas stitching machine	1.3
Hercules stitching machine	0.8
Automatic stitching machine	0.9
McKay stitcher	0.2
Puritan stitcher	0.2
Sewing machines	0.1 -0.2
Knox end splitter	0.6
Stanley leather splitter	0.6
Amazon No. 7 skiving machine	0.3
Tip skiver	0.3
Stiffening skiver	0.1
Goodyear channeling machine	0.1
McKay channeling machine	0.1
Welt and turn machine	0.1
Fisher channel turner	0.1
Goodyear channel turner	0.1
McKay leaf turner	0.1
Tip turner	0.1

Horsepower Input to Shoe Machinery, cont.

	Horsepower
Consolidated hand laster	0.5
Lasting machine	0.3
Pulling-over machine	0.1
Adams sole cutter	2.0
Single sole molder	0.8
Counter molder	0.6
Twin molder	0.8
Crimping machine	0.5
Clicking machine	0.1
Cementing machine	0.1
Beating-out machine	0.2
Sole-laying machine	1.5
Slugging machine	0.5
Leather roller	0.2
Staple-fastening-machine	0.2
Chicago wire fastener	0.3
Knox beam dinker	0.2
Goodyear welt machine	0.4
Welt beater	0.1
Leveler	2.0
Four-foot die press	2.0
Sole trimmer	1.0 to 3.0
Edge trimmer	1.0
Edge pricker	0.1
Single-edge setting machine	0.4
Union twin-edge setting machine	0.4
Eyelet machine	0.2
Buttonhole machine	0.1
Lightning heel-nailing machine	2.0
Mayo heel-nailing machine	2.5
Heel-trueing machine	0.3
Heel scourer	0.4
Heel burnisher	0.3
McKay heel trimmer	2.0
Pricking machine	0.5
Heel shaver	1.5
Sandpaper machine	0.1
Buffing machine	0.2

TEXTILE MACHINERY.

Although the cost of power in textile mills is not five per cent. of the value of the product, still the large size of the mills and the great value of this product enables great savings to be made in this department. It is said that the use of motors in cotton mills has been the means of increasing the production from two to ten per cent., depending on the efficiency of the installation. This branch of the textile industry has attained the largest growth of any, the annual value of cotton products in the United States being more than $530,000,000. In the Southern states, particularly in North and South Carolina, will be found, by far, the largest number of cotton mills.

Before attempting an analysis of the power requirements and applications a clear understanding of the cycle of operations must be had. First, the raw cotton from the bales is drawn, usually by means of a suction conveyor, to the picker room. In the opener and breaker picker the cotton is beaten, the fibers loosened and the material converted from a dense matted mass to a light flaky one. During this operation, also much of the dirt and sand is removed from the cotton. The fiber then passes to the intermediate and then to the finishing pickers, each of these machines again beating the cotton, cleaning it and finally passing it to perforated screens which compress the fiber and deliver it as a lap which is formed into a roll.

The carding room is the next department into which the cotton is taken. The rolls from the pickers are placed on the carders where the fibers are drawn approximately parallel by a combing process. The stock enters these machines as a sheet of lap and is

converted into what is called sliver, a round string-like mass about one-half inch in diameter.

The use of combing machines in a mill depends entirely on the product being manufactured. In mills producing a fine grade of yarn the combing process follows carding. The combing machines supplement the work of the cards, sorting out the fibers to a uniform length. The cotton leaves the combing department in exactly the same form as from the carding room.

Drawing is the next operation, the drawing frame receiving the sliver from either the combers or cards. This machine simply carries on to a greater degree the operation of drawing the fiber parallel. In this machine, however, several ends of the sliver are fed between sets of drawing rolls and are drawn out into a single sliver approximately equal in dimensions to the sliver fed into the machine.

The first twist given the yarn is on the slubbers. Sliver from the drawing frames passes to the slubbers, which are equipped with drawing rolls and spindles, upon which bobbins are revolved, winding the drawn and slightly twisted stock. The slubbing, which is the name of the product as it leaves these machines, is then taken to the roving frames, where it is further drawn out, twisted and wound on bobbins. The yarn then usually passes to intermediate frames and fine frames, these machines simply supplementing the drawing and twisting processes previously given the yarn.

The final preparatory process is spinning and the capacity of a mill and the grade of the product depends on these machines. On the spinning frames the yarn is still further drawn out and given its final twist. Spinning is accomplished by either ring or

mule frames. In the Southern mills ring spinning is almost exclusively employed. From the spinning room the yarn is sized and is either taken to the weave room or other mills.

The foregoing outline gives an idea of the processes involved in the manufacture of cotton and it can be seen that the requirements are such as to render electric drive advantageous.

Power requirements.

It is not feasible to give any specific figures on the power requirements for mills since in no two installations are the conditions the same.

Pickers are perhaps the largest individual power users in a mill. The horsepower required to drive depends upon output and whether the machine is a single or double-beater picker. From 4 to 6 horsepower is usually applied to pickers. These machines are idle about 25 percent of the time.

Carding machines require about one horsepower each. They are idle about 10 percent of the time for doffing.

Draw frames require about 0ne-half horsepower per head. These machines are idle about 20 percent of the time.

The power requirements of slubbers and rovers vary with the number of bobbins, but averages about two horsepower per frame. About 10 percent is allowed for stoppage time.

It is hard to specify the power requirements of spinning frames, as so many items have to be taken into consideration, such as speed of spindles, tightness and character of spindle band, humidity, temperature, character of stock, etc. Generally, about one horsepower per 70 spindles is taken as an average figure. An allowance of about 10 percent is made for stoppage.

The power requirements of looms also varies greatly. The power required depends upon the size of the loom, which is determined by the size of the cloth, the character of the goods and the construction of the loom. The requirements vary from 0.25 to 2 horsepower per loom.

In considering the nature of the textile load it will be found that a very large proportion of textile machines are required to run at constant speed. For this reason the most suitable type of motor is the alternating-current motor, simplicity and lower cost being the greatest.

The advantages of electric drive in cotton mills apply as well in other textile industries. The continuity of output, constant speed and reliability of the induction motor are all desirable in this class of work.

VENTILATION.

Power requirements of fans, blowers, and exhausters.

The use of air in industrial work as a carrier of heat, obnoxious gases, finely divided solids, etc., has become more common than many imagine. Every time a certain volume of air is moved, a certain definite amount of power is required, regardless of the use to which the air is put, but depending upon the velocity with which is it moved and the resistance in its path. There is no simple rule for solving all problems, but each should be considered by itself and all conditions taken into account. Fans, blowers, and exhausters are classified in three distinct groups according to the mechanical construction and principles involved, namely, - centrifugal, disc and positive. Any type of rotary air or gas-handling device can be either a blower or an enhauster depending on whether the device is used to drive the gas into a container or to draw it out.

Centrifugal Fans are those in which the gases are drawn in axially and discharged tangentially. Mechanically this type consists of a number of rotating vanes which are generally enclosed in a housing so as to direct the blast. The centrifugal type includes steel plate fans, "Sirocco" fans, multivane fans, volume and pressure blowers, and cone fans, the latter being substantially a steel plate fan without housings. The name "Steel Plate" is used by all manufacturers to indicate that the housing is made of steel plate riveted or bolted to structural steel shapes. These fans and exhausters are adapted to a wide range of service, being especially suitable for heating and ventilating of buildings and mines, drying systems for brick and lumber, and exhaust systems

for handling fine material, gasès, etc. The amount of air to be handled determines the size of fan required, and the kind of material conveyed by the air determines the air velocity and type of wheel. Air velocities of about 3500 ft. per minute are customary for planing mill refuse; for light shavings a somewhat lower velocity can be used; green sawdust from a band saw mill will require from 4000 to 4500 ft. per minute.

The word "Sirocco" when applied to a fan or blower is a registered trademark, used by The American Blower Company, to designate a type of centrifugal fan having a patented runner, for which performances considerable better than those of the ordinary blower are claimed. This type of fan is much used for heating and ventilating, drying systems, mechanical draft and the like, but is not applicable to conveying systems handling solid matter.

<u>Disc or propeller Fans</u>.are those in which the gases are drawn in axially and discharged axially. This type is too well known to require description; the blades are made in a number of shapes depending on the service and the ideas of the manufacturer. Disc fans are applicable only where large volumes of air or gas are to be handled at very low pressures. This type of fan is widely used for ventilation of buildings, the smaller sizes being mostly used as exhausters, drawing out vitiated air vapors and fumes, and the larger sizes being used in connection with heating systems, for blowing air through heating coils into a chamber for distribution throughout the building. The larger sizes are in common use for mine ventilation.

<u>Positive Pressure Blowers</u> are rotary air pumps which deliver

approximately a constant volume of air per revolution regardless of the pressure, hence the name "positive". This type is made in a large range of sizes and usually consists of two revolving elements between which a certain volume of gas is entrapped and transferred from the inlet to the outlet with only a small amount of leakage. Since the two impellers must maintain a constant angular relation they are geared together so as to rotate in opposite directions and ordinarily are geared to the driving motor. Positive pressure blowers are used mainly for pumping illuminating gases, furnishing blast for forges, cupolas and smelters, and for other purposes requiring a given volume of gas at pressures from about twelve ounces to eight pounds per square inch.

The power required to drive any type of fan is a function of the volume of air handled and the pressure or vacuum obtained. The pressure is usually measured in ounces per square inch, but is often expressed in inches of water indicated by a water gauge, the measuring instrument commonly used, and which is located at the inlet or outlet of the fan.

The cubic foot is usually taken as the unit of volume and is expressed in terms of free air or gas, that is, cubic feet of air or gas at atmospheric pressure. The unit of time most generally used is the minute.

Where
P = Pressure per square in in ounces.
WG = Pressure in inches water gauge.
Q = Cubic feet per minute.
K = A constant.

CENTRIFUGAL FANS.

Then the Brake horse-power at shaft $= \dfrac{K \times Q \times WG}{33000 \times Eff.}$

K = 5.2 for centrifugal fans

Eff.= efficiency of fan expressed as fraction
= 0.40 for steel plate, 0.48 for Sirocco and 0.60 for cone type fans.

The following mathematical relation - are theoretically true for all centrifugal and may be used in calculations:- Volume varies as the speed; pressure varies as the square of the speed; and horse power varies as the cube of the speed.

Disc Fans. The pressure are very low in the service covered by disc type fans and it is customary to figure on the basis of velocity rather than pressures. In this type, also, the above general relation between volume, pressure, and horse-power are true. If however, the outlet is restricted, the power and pressure will both increase until, with an entirely closed discharge, about twice as much power is required as with an unrestricted outlet.

Positive pressure blowers and exhausters. The horse-power required for positive pressure blowers and exhausters may be approximated very closely by the following rule used by the manufacturers:- Allow five horse-power for every 1000 cubic feet per minute displaced against a pressure of

Power requirements of fans, blowers etc. cont.

16 ounces per square inch; thus it will require 15 HP for a blower displacing 2000 cubic feet per minute against 24 ounces pressure. For handling air the volume delivered varies from 80 to 90% of the displacement, and for service as gas exhausters, only from 60 to 75% of the displacement is delivered. Since the volume discharged is approximately constant, regardless of the pressure, any reduction of the inlet or outlet will greatly increase the power required.

For tables of power required to drive different sizes of fans and blowers see catalogues of American Blower Co. for very complete data.

TABLE I - SCHEDULE OF MOTORS FOR HEATING AND VENTILATING APPARATUS

Direct-Current, 240 Volt Motors

Apparatus	Hp.	Speed Max.	Speed Normal	Speed Min.	Efficiencies Full-load	Efficiencies Three-fourths Load	Efficiencies One-half Load
200-in. blower	45	136	119	90	83	82½	80½
200-in. blower							
200-in. blower	45	136	119	90	83	82½	80½
200-in. blower							
Main air supply.							
160-in. blower	12	170	150	112	75½	75½	72
Basement exhaust.							
160-in. blower	8	170	150	112	75	74	71
Basement exhaust.							
90-in. blower	3	300	260	195	80	78	73
90-in. blower	3	300	260	195	80	78	73
East front - second and third floors.							
66-in. propeller fan	3	175	152	115	80	78	73
Exhaust through							
66-in. propeller fan	3	175	152	115	80	78	72
Skylight.							
66-in. propeller fan	3	175	152	115	80	78	73
66-in. propeller fan. First-floor Workmen.	3	175	152	115	80	78	73
48-in. propeller fan	2	400	350	262	80	78	73
Exhaust east foyer- first floor							
Two 66-in. propeller fans	5	240	200	150	75	74	71
Two 66-in. propeller fans	5	240	200	150	75	74	71
Main exhaust from super-attic.							
Two 66-in. propeller fans	5	240	200	150	75	74	71
Two 66-in. propeller fans	5	240	200	150	75	74	71
Main exhaust from super-attic.							

Table 1 (Cont.

Direct-Current, 240 volt-motors

Apparatus	Hp.	Speed Max.	Speed Normal	Speed Min.	Efficiencies Full-load	Efficiencies Three-fourths Load	Efficiencies One-half Load
42-in. multivane fan. Rear basement exhaust.	5	...	240	...	76	74½	71
15-in. multivane fan. Exhaust locker room, basement; 120-volt motor.	0.125	..	425	...	80	78	73
15-in. multivane fan.	0.7	...	900	...	80	78	73
15-in. multivane fan.	0.92	...	975	...	80	78	73
15-in. multivane fan.	0.82	...	950	...	80	78	73
15-in. multivane fan. Exhaust for toilet; local ventilation.	1.00	...	750	...	80	78	73
24-in. multivane fan. Exhaust northeast pavilion, second and third floors.	1.00	...	400	...	80	78	73
24-in. multivane fan.	1.00	...	400	...	80	78	73
Multivane fan. Exhaust for ejector pit.	.125	...	600	...	..	...	..
5-in. turbine pump. Circulation hot water.	10.0	750	650	490	9	78	75
5-in. turbine pump. Direct-heating system.	10.0	750	650	490		78	75
2-in volute pump.	2.0	...	1200	...	80	78	73
2-in. volute pump. Return condensation to boiler plant	2.0	...	1200	...	80	78	73
1½-in. centrifugal pump. Expansion tank supply	0.5	...	1080	...	80	78	73
6-in. volute pump. Circulation of water for air washers.	15	650	570	430	85	83	79

Table I (Cont.

Direct-Current, 240 volt-motors

Apparatus	Hp.	Speed Max.	Speed Normal	Speed Min.	Efficiendes Full-10ad	Efficiendes Three-fourths Load	Efficiendes One-half Load
6-in. volute pump	15	650	570	430	85	83	79
2-in. volute pump	2.0	...	1200	...	80	78	73
Drainage, south air washer, steam and hot-water systems.							
2-in. volute pump..................	2.0	...	1200	...	80	78	73
Drainage, north air-washer.							
3½-in. by 4-in. air compressor.....	1.5	...	1700	...	..	..	..
3½-in. by 4-in. air compressor.....	1.5	...	1700	...	..	..	..
Air supply for thermostatic system valve and damper control							

WOODWORKING MACHINERY.

The operation of woodworking machinery by electricity effects a great saving over shaft and belt drive. The scattered condition of the machines required by the large amount of stock necessary causes long lines of shafting to be used and as the machinery is in use only intermittently, large losses occur in the operation of this shafting. If individual drive is used, most of these losses are eliminated as power is very efficient. The lack of shafting and belting enables the operator to handle his work much more efficiently and also permits of more advantageous placing of the machines.

Woodworking Machinery.

Applications.

Elk River Mill, Elk River, Idaho.

Saw Mill.

1-	200 HP	900 RPM	motor belted to band saw.			
1-	50 HP	1800 TPM	"	D.C.	to	6' Edger.
1-	75 HP	1800 RPM	"	"	"	8' "
1-	40 HP	600 RPM	"	"	"	Slasher.
1-	30 HP	720 RPM	"	"	"	Trimmer.
1-	40 HP	720 RPM	"	"	"	Hog.
1-	40 HP	900 RPM	"	belted	"	Bull chain.
1-	10 HP	1200 RPM	"	"	"	Chain saw.
1-	15 HP	600 RPM	"	"	"	Slasher conveyor.
1-	25 HP	1200 RPM	"	"	"	Burner.
1-	15 HP	600 RPM	"	"	"	Slab.
1-	15 HP	600 RPM	"	"	"	Cross.
1-	10 HP	600 RPM	"	back geared, chain driving Sawdust Conveyor.		
1-	15 HP	600 RPM	"	belted to Boiler room conveyor.		
1-	10 HP	600 RPM	"	" " " " "		
1-	15 HP	600 RPM	"	back geared belted to Slasher chains.		
1-	15 HP	600 RPM	"	" " " " Trimmer "		
1-7.5	HP	900 RPM	"	" " chained " Log deck "		
1-	25 HP	1200 RPM	"	" " belted " Timber chains & rolls.		
1-	10 HP	1200 RPM	"	belted to Incline chains.		

Planing Mill.

1-	50 HP	600 RPM	motor	D.C.	to	Band resaw.
1-	75 HP	1200 RPM	"	belted	to	10 Planers.
1-	30 HP	1200 RPM	"	"	"	Inside moulder.

1-10 HP 1200 RPM motor belted to Outside moulder.

1-5 HP " RPM " " " 2 Rip saws.

1-5 HP " RPM " " " Cut-off saw.

1-50 HP 514 RPM " D.C. " 2 Exhaust fans.

1-50 HP 900 RPM " belted " Charger.

Sash and Door Factory. Load Factor 4.4%; Operating L.F. 25%.

1- 2 HP 1800 RPM motor belted to #7 Mortising machine.

1- 2 HP " RPM " " " Tenoning "

1- 3 HP " RPM " " " 16" Rip saw.

1- 5 HP " RPM " " " 2000# elevator.

Sash and Door Factory. Load factor 1.2 %; Operating L.F. 6%.

1- 2 HP 1700 RPM motor belted to 36" Band saw.

1- ½ HP " RPM " " " 16" x 8' Pattern lathe.

1- 2 HP " RPM " " " 12" Cut-off saw.

1- 5 HP " RPM " " " 12" Rip saw.

1- 2 HP " RPM " " " 4" sticker.

1- 2 HP " RPM " " " 16" Jointer.

1- 1 HP " RPM " " " Sanding machine.

1- 1 HP " RPM " " " Bit mortiser.

1-7.5 HP " RPM " " " 24" Pony planer.

Sash and Door Plant. Load factor 10.9%.

1-7.5 HP 1120 RPM motor belted to mortiser and 2 sanders.

1- 5 HP " RPM " " " American # 2-½ Shaper.

1- 5 HP " RPM " " " " # 2-½ Tenoner & Mortiser.

1- 3 HP " RPM " " " H. B. Smith Sticker.

1- 3 HP " RPM " " " American Cut-off Saw.

1- 2 HP " RPM " " " " Swing Saw.

1- 3 HP " RPM " " " 30" Superior Band saw.